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Assessment of Cod in Division 4X in 2006

Évaluation de la morue de la division 4X en 2006

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ABSTRACT

Biomass has remained low for 4X Cod since 2000 when the quota was reduced to 6000 t to promote rebuilding. There is no indication of a decline in total mortality or relative fishing mortality since 2000. While landings of about 4,000t are contributing to a continuing decline in abundance, further restriction of the directed fishery may not be sufficient to lead to an increase in population. Removals from all fisheries should be reduced to as low a level as practicable.

RÉSUMÉ

La biomasse de la morue de 4X est peu élevée depuis 2000, année où le quota a été réduit à 6 000 t pour favoriser la reconstitution du stock. Rien n'indique qu'un déclin se produit au niveau de la mortalité totale ou de la mortalité relative par la pêche depuis 2000. Même si des débarquements d'environ 4 000 t contribuent à maintenir le déclin de l'abondance, l'application d'autres restrictions à la pêche dirigée ne pourrait suffire à provoquer une augmentation de la population. Aussi, les prélèvements de toutes les pêches devraient être réduits au plus bas niveau possible.

INTRODUCTION

In the 1960s, landings of 4X cod (including landings from Canadian portion of 5Y; Fig. 1) increased as domestic and foreign otter trawl fleets joined the fishery, then dropped in 1970 as effort declined due to restrictions on haddock fishing (Fig. 2, Table 1). Recent landings reflect the restrictive total allowable catch (TAC). The TAC from 2000-2004 was 6000 t annually and landings dropped to the lowest recorded in 2005 at 4000 t. As of November 3rd, 2832 t of the 2006 quota had been landed.

DESCRIPTION OF THE FISHERY

The distribution of the fishery has shifted in recent years, with Georges and Crowell basins in 4Xp increasing in importance (Table 2, Fig. 3). In 2006, a significant part of the landings were taken on Browns Bank. Landings in 4Xmno were the lowest on record in 2004. This redistribution of fishing effort is a general pattern in the groundfish fishery, and reflects shifts in fishing patterns and distribution of abundance for a number of species. The proportion of landings coming from 4Xp has been increasing, and in 2006, 4Xp landings constitute the highest proportion of the overall landings on record (Fig 2).

The fishery takes place year-round (Table 3). Landings peaked in summer in most years, but recently have been more evenly divided throughout the year.

4X cod is caught as part of a mixed species fishery. Generally, in the last decade, cod and haddock quota had been fully utilized, while some pollock quota was left uncaught (Table 4). In 2001-2003, cod was reported to be the limiting species in the fishery. Participants in the fishery were trying to avoid cod while targeting haddock. This pattern has changed, and in 2004 and 2005, neither the 4X cod nor haddock quotas were caught, while most of the pollock quota was landed (table 4). In 2005, pollock quota appeared to be limiting for both gillnet and otter trawl<65'. This is again the pattern in the 4X fishery in 2006. It seems unlikely that either the cod or haddock quota will be fully utilized, while the pollock quota will be landed by most groups.

For the past several years, fishing has been poor in most coastal areas (Clark et al 1998; Clark, 2005). Poor fishing for both cod and haddock inshore have contributed to a decline in fishing effort, particularly by hook and line vessels. The number of vessels active in the fishery in 4X continues to decline, particularly for handline, which has all but disappeared (Table 5a), and reported fishing effort for groundfish dropped in 2005 for hook and line vessels (Table 5b). Data on days fished are not available for much of the fleet prior to 1996, however the total number of trips by gear type had declined by 1996 from a peak in 1992 (Clark, 1997).

Discrepancies in species composition between trips carrying an observer and unobserved trips may be indicative of potential discarding or misreporting of

landings. While discarding of cod may have been an issue in some years, it is unlikely to have been an issue in 2005 or 2006, since the quota does not appear to have been limiting.

The level of observer coverage in 4X has generally been below 1% (Table 6), too low for any meaningful comparisons. Observer coverage has remained low in 2006. Much higher coverage, stratified to account for geographic variability in the fishery, would be required to make useful comparisons of observed and unobserved trips. Experience with the 5Z groundfish fishery suggests that 10% observer coverage may not always be sufficient for detecting potential discarding (DFO, 2003; Clark, 2005).

CATCH-AT-AGE

Fishery Samples

Sampling of the commercial fishery in 2006 is restricted in some areas. There are few samples from the fixed gear in 2006, and only 6 samples (3 in the first half of the year and 3 in the second half) from 4Xmno, despite the fact that this accounts for over half the landings. Catch at age was derived following standard protocols for this stock (Clark and Hinze, 2003). Construction of the catch-at-age for the first half of 2006 is detailed in Table 7.

Landings

The size composition of the catch peaks at about 55 cm (22 in), with a smaller mode at 75 cm (30 in) for both the Scotian Shelf and Bay of Fundy commercial landings (Fig. 4). The modal lengths reflect the dominant recruiting 2003 yearclass, and the 2001 yearclass.

Modal lengths are usually higher in the Bay of Fundy, due to the faster growth. The lack of any clear difference in 2006 reflects a blend of samples of fast and slow growing fish coming from on top of Browns Bank and in deep water of 4Xp. With the increased contribution of 4Xp to the overall landings in 2006, much of the commercial sampling is coming from an area where both growth types overlap.

The 2001 yearclass (age 5 in 2006) was dominant in the fishery in 2005 and the first half of 2006 (Fig. 5, table 8). The 2003 yearclass comprised a larger share of the catch-at-age in June, and later in the year. There are very few cod over age 6 in the catch in recent years, and the proportion of the catch comprised of cod over age 6 has been low since the late 1980s (Figure 5 b, Figure 5c). As in the first half of 2005, there are no age 2 cod in the catch in the first half of 2006. These fish may, however, contribute to the landings later in the year as they increase in size.

ABUNDANCE INDICES

Catches of cod were distributed throughout the management area in the RV survey; however there were no large catches at any location (Fig. 6). The ITQ survey caught few cod at any station in the Bay of Fundy in 2006 (Fig. 7). Catches were also small in most areas on the Scotian Shelf, except on Roseway Bank. Catches were below median at almost all stations in the Bay of Fundy and Gulf of Maine, while the number of stations with catch above and below the median on the Scotian Shelf were about equal (Fig. 8). Both the proportion of non-zero sets and the proportion where the catch was above the median have been declining for the Bay of Fundy (Fig. 9).

In the Bay of Fundy the RV and ITQ survey biomass indices have both declined since 2000, despite the reduction in quotas which were intended to promote rebuilding. The biomass indices in the Bay of Fundy in 2006 were the lowest in the series for both surveys (Fig. 10).

On the Scotian Shelf, the RV survey biomass index has been declining since the late 1990's and in 2006 is the lowest in the series (Fig. 10). The ITQ survey biomass index also remained low.

Catches in the RV survey were very low in the Bay of Fundy for most commercial sizes, but were close to median levels for smaller sizes (Fig. 11). Catches are below the median on the Scotian Shelf for almost all lengths. In the ITQ survey, catch was below median at all lengths in the Bay of Fundy, while the catch was close to median for most lengths on the Scotian Shelf (Figure 12).

Lengths at age for 4X cod from the RV survey are stable for both the Fundy and Shelf regions (Figure 13). Similarly, there are no persistent trends in commercial weights-at-age (Table 9).

The indices at age for the RV and ITQ surveys show abundance of older fish is very low in recent years (Figure 14 and 15; Tables 10 and 11). For younger ages, the ITQ survey index on the Shelf is the second highest in the series for age 3, but low for age 2 (Figure 15, Table 10). Indices for the Fundy region are low at all ages. The 2003 year-class dominates the RV survey catch in both the Fundy and Shelf regions, but is still slightly below the median for age 3 (Figure 14, Table 11). The recruitment indices (age 2) from the RV survey are below the median in both areas.

Condition (Fulton's K) has been very stable in the Bay of Fundy (Figure16). Cod from the Scotian Shelf have shown greater variability in condition. Condition has dropped in the last two years, and is now similar to levels observed in the late 1980's and early 1990's.

Total mortality (Z) calculated from the RV survey displays high interannual variability, but with a 3-year smooth, some trends can be seen (Figure 17). Estimates of Z from the RV survey are high, with some recent increase for both the Scotian Shelf and Bay of Fundy. Looking at survey Z for a cohort averaged over a series of years, Z for a cohort appears to be increasing for commercial ages but not for juveniles (Figure 18). Total mortality calculated for the ITQ survey is variable; no clear trend is evident for the Bay of Fundy, while Z may be increasing on the Scotian Shelf (Figure 19). The relative fishing mortality (catch biomass/ survey biomass index) while generally lower since 1995 than in the previous decade, appears to be increasing, and has not declined since the TAC was dropped to 6,000 t in 2000 (Figure 20). The absence of any decline in total mortality or relative fishing mortality indicates that the reduction in landings since 2000 has not led to a reduction in mortality.

VIRTUAL POPULATION ANALYSES

Abundance estimates from Virtual Population Analysis have not been included in the 4X cod assessment since 2002. A substantial retrospective pattern led to the abandonment of VPA as a basis for the assessment. The retrospective was thought to indicate substantial unaccounted mortality, and appeared to be highest on fishable ages (Clark and Hinze, 2003). Given the continued decline in survey catches, and lack of older fish in either surveys or the commercial catch, some VPA results are provided for illustrative purposes.

ADAPT (Gavaris, 1988) was used to calibrate a sequential population analysis with RV and ITQ survey indices (indices used for ages 2-8; years 1983-2006 for RV and 1996-2005 for ITQ). This formulation had been used in previous assessments (Clark and Paul, 1999).

The results from this VPA suggest there has been a steep decline in biomass and abundance in recent years (Figure 21, Table 12). The scaling factors (q's) between the survey and population, however, show a pronounced trend (Figure 22). This trend of increasing q reflects that, for a given survey catch, the estimated population is now much lower than in the past. Some change in q is quite likely for this stock. The inshore fishery, which accounted for a large proportion of the landings, was quite active in July prior to the mid-1990's in areas not covered by the survey strata. With the collapse of this fishery much of which was a handline fishery, the proportion of the overall stock which is in the surveyed area, and available to the survey, has likely increased.

Attempting to model the population with a change in 'q' in 1993 results in even lower estimates of current abundance, but also results in estimates of q which are over 1, which is not plausible. Running separate models for the Scotian Shelf and Bay of Fundy, for which landings data are available separately only back to 1993, resulted in similarly very low abundance estimates. No major differences in f

trends for the two regions are apparent (Figure 23), and the decline in biomass is seen in both areas.

Allowing ADAPT to calculate f in the time block 1996-2006 results in high f, but also high estimates of recent recruitment, which are not consistent with the RV indices at younger ages. If f is fixed at 0.2 for ages 1-3, and calculated for ages 4 and over, the estimates of recruitment are not as high. This formulation results in a pattern of q at age which is more stable over time, and estimates current m for older ages as 0.8. Using this model, estimates of population numbers at age and total biomass are roughly double what are estimated from the model which has no change in 'm'.

These model formulations are presented as bounds on the possible population abundance and biomass of 4X cod. Using the standard formulation, as in Clark and Paul, 1999, estimates a very low population, with diagnostics that suggest the population may be under-estimated. Using a formulation which estimates natural mortality at 0.8 for older ages produces a higher population estimate, but indicates most will succumb to natural mortality. All of the model formulations investigated result in population biomass estimates (ages 3+) which are at their lowest point, and which are below the long term landings for 4X cod of about 20,000 t. The available yield at an F of 0.2 (using weights at age and partial recruitment from Clark and Paul, 1999) ranges from about 1,500 t to 3,000 t. At these harvest levels, there is no projected biomass increase.

CONCLUSIONS

Despite the low landings in recent years, survey catches indicate there has been no increase in biomass for 4X cod; instead, there has been some decline in biomass. Mortality estimates also show no indication of decline. In addition, survey recruitment estimates are low for the 2004 year-class. Landings of about 4,000 t, as reported for 2005, and anticipated for 2006, do not appear to be sustainable for this resource at present. The illustrative VPA results are consistent with these conclusions from survey and fishery data.

While landings of about 4,000t are contributing to a continuing decline in abundance, further restriction of the directed fishery may not be sufficient to lead to an increase in population. Removals from all fisheries should be reduced to as low a level as practicable.

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Table 1. Canadian landings of cod in 4X (and Canadian portion of 5Y) by gear and tonnage class.

	Otter Trawl					Gill Net		Long Line			Hand		
Year	0&1	2	3	4	5+	0&1	2&3	0&1	2	3+	Line	Misc.	Total
1953	27	87	53	3								12,884	13,054
1954	34	113	17	7						321		13,914	14,406
1955	51	121	6	10						271		12,973	13,432
1956	118	104	42	4					376	414		13,791	14,849
1957	240	173	143						1,777	370		10,916	13,619
1958	240	314	127	52				1	1,197	591		8,581	11,103
1959	552	565	234						1,182	608		9,725	12,866
1960	578	426	229	10		1		2,740	1,007	497	4,802	1,833	12,123
1961	505	735	390	12		520		2,269	1,502	597	4,661	1,232	12,423
1962	565	1,007	971	410		645		2,883	1,337	456	4,571	1,811	14,656
1963	258	877	1,159	1,414		748		2,839	1,021	398	5,417	1,660	15,791
1964	457	1,384	1,510	4,063		750		2,672	1,151	677	5,403	2,700	20,767
1965	466	1,758	2,320	7,857		765		3,502	885	564		6,104	24,221
1966	284	2,023	3,064	7,222	72	851		3,733	513	702		5,700	24,164
1967	269	2,359	3,376	7,281	1,483	1,847		3,027	373	940	5,205	1,653	27,813
1968	253	2,245	3,684	7,596	3,111	1,856	0	3,482	479	806	5,766	1,562	30,840
1969	207	1,385	2,448	4,298	3,721	926	0	3,554	513	681	4,446	1,933	24,112
1970	158	1,151	1,529	1,960	1,259	653	0	4,171	515	768	3,444	2,410	18,018
1971	81	1,097	1,611	1,799	1,220	546	4	5,472	691	1,575	4,421	1,783	20,300
1972	121	1,235	1,635	2,246	1,371	1,187	0	6,119	668	1,174	3,128	1,646	20,530
1973	100	1,214	1,232	1,350	553	669	0	7,407	1,048	1,641	3,672	1,105	19,991
1974	128	1,433	1,310	575	577	1,851	0	6,834	1,400	1,096	3,247	490	18,941
1975	129	2,666	1,298	460	601	1,482	27	6,013	1,600	781	2,526	2,001	19,584
1976	82	1,025	1,263	436	896	2,403	167	4,828	1,067	760	2,690	525	16,142
1977	298	1,972	2,909	527	1,065	2,052	79	6,151	1,831	907	2,943	1,254	21,988
1978	615	1,805	2,573	745	1,731	2,562	96	6,904	2,216	1,149	2,059	1,264	23,719
1979	663	1,749	2,744	1,139	1,405	3,527	116	7,517	2,051	862	4,140	2,770	28,683
1980	1,322	2,769	4,284	1,042	2,037	2,683	61	8,356	2,360	898	4,198	1,267	31,277
1981	1,165	3,086	2,989	416	1,131	2,871	114	10,302	2,555	1,235	5,174	483	31,521
1982	879	3,159	4,493	563	2,217	3,154	214	9,120	3,465	1,087	4,299	484	33,134
1983	638	4,735	6,306	518	1,118	2,180	235	5,747	2,757	883	3,750	604	29,471
1984	964	4,198	5,904	302	1,513	1,248	220	3,916	2,825	980	3,005	453	25,528
1985	523	3,954	5,562	90	1,185	1,837	161	2,617	1,740	635	2,755	440	21,499
1986	573	3,663	5,123	224	974	1,453	196	2,479	1,918	576	2,490	371	20,040
1987	312	2,645	3,504	531	929	1,968	241	3,075	2,175	499	2,670	456	19,005
1988	454	3,966	3,542	160	467	903	444	3,528	3,149	672	3,081	171	20,537
1989	409	3,933	4,184	67	713	1,254	475	2,915	2,167	62	2,937	208	19,885
1990	505	3,668	3,577	268	170	1,933	692	4,201	2,967	849	4,871	203	23,904
1991	355	4,598	5,805	298	751	2,225	619	4,712	3,679	842	3,737	128	27,749
1992	238	4,494	5,711	143	726	1,811	586	4,455	3,574	719	3,517	106	26,080
1993	176	2,778	3,598	68	241	1,387	523	2,768	1,693	310	2,439	45	16,026
1994	132	2,022	2,343	138	82	993	421	2,837	1,412	231	2,367	67	13,045
1995	100	1,387	1,619	112	75	470	507	1,632	959	182	1,706	18	8,767
1996	92	1,552	2,314	157	103	611	442	1,774	1,306	201	1,914	106	10,572
1997	79	2,094	2,430	136	35	694	471	2,013	1,255	231	1,794	6	11,238
1998	99	1,404	1,892	166	22	437	376	1,717	1,016	244	910	0	8,283
1999	86	779	1,253	63	11	501	408	1,551	771	120	762	0	6,304
2000	113	851	1,268	78	9	358	356	1,420	533	106	662	1	5,755
2001	120	975	1,292	29	9	383	390	1,532	423	72	409	0	5,707
2002	181	873	1,484	0	51	524	535	1,559	338	55	292	0	5,893
2003	299	704	1,518	8	5	610	435	1518	350	60	154	7	5,667
2004	269	667	1,513			590	591	1,048	187	20	125	1	5,010
2005	209	660	1,103	21		433	392	1,038	208	12	42	0	4,117
2006	173	354	607	59		211	68	820	190	8	24	0	2,513

2006 landings for Jan. 1 – Sept. 20.

Table 2. Nominal catch of 4X cod by unit area.

Year	4Xm	4Xn	4Xo	4Xp	4Xq	4Xr	4Xs	4Xu	5Y	Shelf	Fundy	Foreign	Total
1956	1,981	1,043	5,909		756	2,648	817	1,695		10,204	4,645	1,663	14,849
1957	1,929	1,447	6,369		934	2,041	616	283		9,957	3,662	1,083	13,619
1958	1,480	1,130	5,056		651	1,859	774	153		7,781	3,322	1,110	11,103
1959	2,212	937	5,302		1,123	2,339	957			8,451	4,419	862	12,870
1960	1,654	963	5,164		885	2,373	828	256		7,973	4,150	1,605	12,123
1961	1,630	1,279	5,275	24	892	2,449	905			8,208	4,246	1,272	12,454
1962	1,520	1,031	6,250	651	768	2,946	1,327	163		9,574	5,082	1,280	14,656
1963	1,862	829	6,861	1,443	767	2,419	1,579			10,995	4,765	1,995	15,760
1964	2,099	2,178	7,174	3,334	1,093	3,572	1,317			14,785	5,982	4,688	20,767
1965	1,665	2,088	6,526	7,733	962	4,091	1,215			18,012	6,268	2,693	24,280
1966	2,201	1,521	5,444	7,254	1,099	4,607	2,032			16,420	7,738	6,746	24,158
1967	2,384	1,400	7,120	8,041	1,276	5,425	2,051			18,945	8,752	4,651	27,697
1968	3,251	2,059	8,159	9,341	1,327	4,785	1,849	4	65	22,813	8,027	4,776	30,840
1969	2,413	2,923	7,355	5,523	947	3,686	1,120	59	60	18,258	5,828	8,704	24,086
1970	2,851	1,300	6,966	2,310	1,077	2,621	847	23	26	13,444	4,577	4,308	18,021
1971	2,750	1,728	9,029	2,157	1,395	2,355	754	13	119	15,674	4,626	3,197	20,300
1972	3,124	1,585	8,908	1,421	1,938	2,818	977	7	52	15,044	5,786	1,902	20,830
1973	2,130	1,478	10,180	1,228	1,742	2,186	802	179	67	15,159	4,833	2,222	19,992
1974	2,243	1,122	9,369	955	1,526	2,839	768	1	120	13,690	5,253	2,166	18,943
1975	81	1,374	967	1,033	864	2,867	133	12,180	86	13,199	6,386	1,598	19,585
1976	1,973	1,408	8,267	743	1,061	2,034	601	40	16	12,423	3,720	519	16,143
1977	184	1,706	1,229	1,487	907	2,686	122	13,562	105	15,456	6,532	378	21,988
1978	2,812	2,864	8,522	3,591	2,286	2,246	676	341	382	18,062	5,658	301	23,720
1979	6,565	2,750	10,495	1,748	2,325	2,550	1,646	229	379	21,741	6,946	78	28,687
1980	5,205	3,325	9,899	1,561	3,571	4,684	2,278	47	166	20,023	10,712	541	31,276
1981	4,767	2,114	12,097	1,830	2,413	5,072	2,031	419	599	21,051	10,290	179	31,520
1982	5,255	2,922	10,451	2,079	3,715	4,571	2,009	538	1,349	20,956	11,933	245	33,134
1983	3,437	1,690	8,537	2,497	3,160	3,787	1,674	1,826	2,543	16,891	12,258	320	29,469
1984	2,255	2,251	6,192	1,655	2,244	2,959	1,414	3,583	2,698	14,110	11,141	277	25,528
1985	3,006	1,199	5,438	1,026	1,999	2,301	1,511	3,608	1,364	12,236	9,216	47	21,499
1986	2,914	1,762	4,670	544	1,754	1,802	1,500	4,469	557	11,748	8,224	68	20,040
1987	2,676	1,611	4,777	1,131	1,240	858	1,207	5,116	360	12,783	6,179	29	18,991
1988	1,502	1,086	5,458	1,271	1,124	850	1,103	7,990	142	14,814	5,711	11	20,536
1989	1,370	1,019	5,506	2,820	1,360	1,112	915	5,267	478	13,855	5,994	38	19,887
1990	1,846	764	7,915	1,746	2,238	1,721	1,722	5,404	326	15,551	8,119	222	23,892
1991	2,552	1,584	8,963	2,440	2,763	4,243	2,560	2,246	307	17,275	10,383	91	27,749
1992	1,523	1,818	10,347	1,455	2,919	3,352	1,503	2,876	278	17,556	8,515	9	26,080
1993	1,364	1,646	4,845	1,436	1,959	2,428	1,399	760	189	9,406	6,620	0	16,026
1994	828	561	4,414	1,128	1,662	1,883	892	1,540	137	7,942	5,166	0	13,108
1995	293	696	1,737	1,586	1,306	1,032	510	1,528	79	3,349	5,500	0	8,849
1996	466	813	2,787	1,484	1,608	1,659	930	654	171	4,885	5,755	0	10,640
1997	453	837	2,213	1,327	1,793	2,240	1,070	1,303	183	4,490	7,058	0	11,548
1998	478	907	1,657	1,800	993	1,288	615	394	152	3,369	4,916	0	8,283
1999	401	593	1,591	1,296	964	784	415	140	121	2,748	3,553	0	6,304
2000	291	395	1,433	1,198	1,071	680	413	151	124	2,222	3,535	0	5,756
2001	257	535	1,049	1,395	985	814	441	125	106	2,289	3,418	0	5,707
2002	231	422	901	1,485	1,152	867	487	132	216	1,663	4,219	0	5,893
2003	186	421	700	1,276	723	1,112	695	280	274	1,808	3,853	0	5,668
2004	88	245	360	1,211	926	928	709	289	254	1,081	3,922	0	5,010
2005	99	403	444	1,085	726	584	409	166	201	1,453	2,664	0	4,117
2006	57	261	442	931	288	144	207	151	32	1,625	888	0	2,512

Landings for 2006 from Jan 1 – Sep 20

Table 3. Monthly landings for 4X cod.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Unknown	Calendar year	Fishing year
1960	119	428	235	388	1,565	1,329	2,924	1,365	1,703	934	662	417	0	12,069	
1961	225	298	246	597	964	2,324	2,527	1,397	1,250	1,299	880	416	0	12,423	
1962	63	108	363	904	1,181	1,984	3,473	1,846	1,988	1,157	926	556	0	14,549	
1963	309	122	309	577	1,564	2,896	2,570	2,660	1,933	1,714	777	359	0	15,790	
1964	474	320	832	1,690	1,727	3,182	3,592	2,856	2,417	2,362	899	367	349	21,067	
1965	392	367	1,229	1,881	2,603	3,724	4,694	2,634	2,708	2,377	927	685	0	24,221	
1966	911	755	838	2,061	2,034	3,419	4,299	3,323	2,555	2,470	910	588	0	24,163	
1967	874	823	820	1,462	2,304	5,155	4,210	4,052	3,334	2,962	1,304	513	0	27,813	
1968	871	1,107	1,406	2,377	3,121	5,009	4,952	4,116	2,742	3,037	1,328	774	0	30,840	
1969	1,876	1,694	1,071	1,845	2,160	4,176	3,722	2,797	1,943	1,483	827	518	0	24,112	
1970	805	500	617	970	2,024	2,745	2,775	2,279	1,969	1,874	921	541	0	18,020	
1971	526	848	584	814	1,725	3,939	3,328	2,483	2,487	1,902	1,110	555	0	20,301	
1972	862	633	473	744	1,258	3,832	3,982	2871	2038	2663	925	250	0	20,531	
1973	1,009	925	514	1,056	1,381	3,919	2,937	2,623	2,264	1,544	818	1,001	0	19,991	
1974	771	397	399	695	1,335	3,583	3,150	2,538	1,968	1,765	877	1,464	0	18,942	
1975	648	169	394	712	3,223	3,250	3,355	2,647	1,796	1,457	668	1,267	0	19,586	
1976	363	555	376	581	1,220	2,824	2,869	2,064	1,968	1,399	782	1,140	0	16,141	
1977	580	940	861	1,580	2,232	3,782	3,366	2,444	1,740	2,048	1,443	973	0	21,989	
1978	862	2,042	911	1,371	1,987	3,411	3,379	2,920	2,454	1,473	1,085	1,828	0	23,723	
1979	889	752	1,973	1,400	1,846	4,276	3,638	3,555	3,218	2,233	2,992	1,935	0	28,707	
1980	706	2,188	1,704	2,485	3,317	5,316	3,433	3,346	2,603	2,876	1,547	1,756	0	31,277	
1981	1,649	2,451	2,529	1,533	2,881	4,093	3,845	4,067	2,253	3,119	1,728	1,373	0	31,521	
1982	757	2,390	2,569	1,491	3,415	5,109	4,734	3,258	3,540	2,890	1,244	1,737	0	33,134	
1983	1,713	1,654	1,648	1,888	2,743	5,713	4,554	2,832	3,183	1,787	1,037	719	0	29,471	
1984	1,798	2,021	752	817	1,796	3,471	3,688	4,567	2,773	1,668	1,201	976	0	25,528	
1985	779	1,699	956	1,268	1,974	2,586	3,199	2,650	2,737	1,801	787	1,063	0	21,499	
1986	904	1,633	1,775	1,450	1,437	1,939	2,739	1,995	2,576	1,714	771	1,107	0	20,040	
1987	1,208	1,837	1,242	1,059	1,870	2,778	2,663	1,821	1,679	1,403	910	535	0	19,005	
1988	2,104	1,531	535	939	1,620	2,931	3,104	2,122	2,524	1,441	636	1,050	0	20,537	
1989	2,150	2,347	1,362	1,707	1,292	3,562	1,830	1,772	1,535	1,278	637	413	0	19,885	
1990	2,619	2,027	707	778	1,560	3,104	3,751	3,123	2,598	1,689	1,158	790	0	23,904	
1991	2,023	2,651	993	1,666	2,322	3,167	3,963	2,881	2,967	2,208	1,650	1,258	0	27,749	
1992	2,088	1,740	1,297	1,502	1,685	3,622	3,366	2,803	2,625	2,353	1,478	1,521	0	26,080	
1993	657	903	994	996	1,617	2,312	2,834	2,221	1,804	1,048	562	78	0	16,026	
1994	734	972	547	847	824	1,771	2,246	1,503	1,267	1,154	726	454	0	13,045	
1995	610	229	317	827	574	1,236	1,771	774	1,071	521	276	561	0	8,767	
1996	503	331	446	531	819	1,755	1,805	1,317	880	887	679	619	0	10,572	
1997	98	362	378	806	644	1,440	1,779	1,382	1,548	1,424	710	668	0	11,239	
1998	285	348	402	313	512	955	1,290	978	1,150	793	528	729	0	8,283	
1999	186	105	124	331	416	1,056	1,296	868	872	479	333	239	0	6,304	7,330
2000	215	255	556	113	3o8	906	1,104	755	545	507	324	107	0	5,755	5,834
2001	361	103	641	315	449	745	870	672	594	470	318	169	0	5,707	5,908
2002	376	278	561	624	493	677	841	744	567	360	230	141	0	5,893	5,817
2003	296	160	685	289	475	442	565	776	800	569	401	209		5,668	5,399
2004	118	224	529	451	513	432	641	569	593	424	245	271		5,010	4,857
2005	194	289	235	351	281	245	457	583	445	437	315	289		4,121	3,847
2006	217	67	159	71	116	364	656	649	596					2,896	2,452

Landings for 2006 from Jan 1 – Sep 20

Table 4. Proportion of groundfish quotas landed in the 4X fishery by gear sector.

1998 Quota Report	cod	haddock	pollock
FIXED < 45'	84%	94%	75%
MOBILE <65' (ITQ)	99%	100%	81%
VESSELS >100'	89%	86%	61%

1999 Quota Report	cod	haddock	pollock
FIXED < 45'	92%	82%	65%
MOBILE <65' (ITQ)	93%	99%	75%
VESSELS >100'	72%	99%	59%

2000 Quota Report	cod	haddock	pollock
FIXED < 45'	97%	97%	80%
MOBILE <65' (ITQ)	107%	103%	77%
VESSELS >100'	90%	92%	29%

2001 Quota Report	cod	haddock	pollock
FIXED < 45'	96%	77%	82%
MOBILE <65' (ITQ)	104%	100%	73%
VESSELS >100'	89%	95%	28%

2002 Quota Report	cod	haddock	pollock
FIXED < 45'	96%	94%	72%
MOBILE <65' (ITQ)	102%	99%	91%
VESSELS >100'	65%	80%	61%

2003 Quota Report	cod	haddock	pollock
FIXED < 45'	84%	60%	74%
MOBILE <65' (ITQ)	104%	100%	97%
VESSELS >100'	91%	93%	87%
Aboriginal Fishery	98%	82%	70%

2004 Quota Report	cod	haddock	pollock
FIXED < 45'	70%	30%	78%
MOBILE <65' (ITQ)	91%	74%	99%
VESSELS >100'	85%	66%	91%
Aboriginal Fishery	88%	69%	77%

2005 Quota Report	cod	haddock	pollock
FIXED < 45'	66%	42%	87%
MOBILE <65' (ITQ)	80%	77%	97%
VESSELS >100'	81%	80%	102%
Aboriginal Fishery	68%	64%	88%

2006 Quota Report	cod	haddock	pollock
FIXED < 45'	63%	50%	80%
MOBILE <65' (ITQ)	53%	41%	57%
VESSELS >100'	27%	26%	35%
Aboriginal Fishery	64%	46%	43%

Landings To November 3rd 2006

2005 Quota Report	cod	haddock	pollock
FIXED < 45'	57%	30%	79%
MOBILE <65' (ITQ)	50%	51%	83%
VESSELS >100'	15%	11%	62%
Aboriginal Fishery	41%	36%	56%

Landings To October 27th 2005

Table 5a. Number of fishing vessels reporting landings of cod, haddock, Pollock or white hake annually.

Year	Otter trawl	Gill net	Longline	Handline
1996	142	205	528	779
1997	142	197	497	657
1998	129	163	398	422
1999	129	126	357	354
2000	121	101	376	326
2001	112	97	366	201
2002	113	110	381	162
2003	108	103	339	92
2004	103	98	312	59
2005	91	90	281	41
2006*	83	87	270	24

Table 5b. Fishing days by gear type

Year	Gill net	Longline	Handline
1996	4,912	5,210	9,880
1997	6,281	6,179	9,650
1998	4,178	5,352	5,721
1999	3,370	4,156	4,234
2000	2,321	3,794	3,287
2001	2,116	3,895	2,093
2002	2,253	4,232	1,390
2003	2,432	3,960	711
2004	2,237	3,089	468
2005	2071	2647	250
2006*	1229	2,172	107

Data until September 25th, 2006

Table 6. Proportion of 4X cod landings caught during trips with Observer coverage in the 4X groundfish fishery.

year		otter trawl Tonnage	otter trawl proportion	longline Tonnage	longline proportion
2001	observed	45.4	3.80%	11.1	0.74%
	landed	1188		1500	
2002	observed	0.266	0.01%	6.3	0.30%
	landed	1777		1867	
2003	observed	20.2	0.79%	6.9	0.82%
	landed	2540		842	
2004	observed	88.3	3.60%	12.3	0.99%
	landed	2453		1243	
2005	observed	30.4	1.52%	8.9	0.72%
	landed	1990		1233	
2006	observed	31.8	2.67%	0	0.00%
	landed	1192		1018	

Table 7. Construction of catch-at age for 4X cod in the first half of 2006

Gear	Area	Number of Samples	Number Measured	Landings (t)	Age-length key
Otter Trawl	Fundy	6	1429	427	227 ages
Gill net		1	250	75	
Hook and Line		4	890	28	
Otter Trawl	Shelf	7	1775	327	221 ages
Gill net				15	
Hook and Line		2	271	109	

Table 8a. Catch at age (numbers in thousands) for 4X cod.

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	2+	3+	4+
1980	0	837	6,054	2,358	1,742	1,135	442	261	91	60	19	17	5	13,021	12,183	6,129
1981	0	818	3,870	4,265	1,844	1,045	587	297	184	75	39	19	19	13,061	12,244	8,373
1982	0	904	2,885	4,414	3,060	912	393	279	146	86	41	25	15	13,160	12,255	9,371
1983	9	1,031	3,689	2,433	2,057	1,205	459	204	120	76	36	10	10	11,330	10,299	6,610
1984	33	917	2,393	3,081	1,930	965	465	176	63	49	29	18	5	10,090	9,173	6,781
1985	0	711	1,674	1,569	2,324	1,284	514	194	71	53	18	7	6	8,425	7,715	6,041
1986	0	251	2,789	1,941	994	1,008	409	200	93	50	23	20	10	7,788	7,537	4,748
1987	0	861	902	2,053	1,087	523	511	236	140	66	33	9	7	6,428	5,567	4,665
1988	0	403	3,517	1,659	1,553	656	178	192	85	53	28	6	9	8,338	7,935	4,418
1989	17	655	2,560	3,656	632	562	163	79	60	19	10	10	2	8,408	7,753	5,193
1990	0	144	2,863	2,805	2,462	497	279	78	40	38	14	15	1	9,235	9,091	6,228
1991	2	391	1,535	5,092	1,777	1,364	215	156	32	16	28	15	6	10,626	10,235	8,700
1992	0	751	3,391	1,878	3,276	878	513	63	50	16	9	4	0	10,828	10,077	6,685
1993	0	881	3,490	2,045	660	672	186	90	14	14	5	0	0	8,056	7,176	3,686
1994	0	475	2,280	2,233	887	195	181	42	18	0	2	0	0	6,314	5,838	3,558
1995	0	135	2,146	1,081	582	130	28	40	11	5	0	0	0	4,158	4,023	1,877
1996	0	50	883	2,594	441	212	29	16	8	2	1	1	0	4,237	4,187	3,304
1997	0	59	1,126	1,556	1,193	199	82	16	2	6	1	3	0	4,243	4,184	3,058
1998	0	234	886	1,021	615	441	54	20	6	2	3	1	1	3,284	3,050	2,164
1999	0	72	834	543	347	264	120	20	7	0	0	1	0	2,210	2,138	1,303
2000	0	218	575	905	247	189	66	27	8	1	1	0	0	2,237	2,019	1,444
2001	0	114	1,187	595	378	75	40	17	12	1	0	0	0	2,420	2,306	1,119
2002	0	22	365	1099	221	138	31	16	13	4	1	0	0	1,909	1,887	1,521
2003	0	73	249	557	519	96	95	21	2	1	3	0	0	1,614	1,541	1,292
2004	0	33	1,029	367	291	153	19	20	5	1	0	0	0	1,920	1,887	858
2005	0	66	148	830	173	89	47	9	3	0	0	0	0	1,367	1,301	1,152
2006	0	0	93	69	178	45	9	7	3	0	1	0	0	406	405	312

*Includes Jan-June 30

Table 8b. Catch at age (numbers in thousands) for Scotian Shelf cod.

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	2+	3+	4+
1993		629	1822	1532	547	498	126	64	10	11	3		0	5242	4614	2792
1994		279	1076	1460	703	159	168	43	15	1	1			3905	3626	2550
1995		65	814	463	358	102	28	29	9	2	0			1870	1805	991
1996		12	508	1404	226	115	19	6	6	3	2	0		2300	2288	1780
1997		0	329	836	635	59	56	9	3	5	1	4		1936	1936	1607
1998		156	440	550	364	213	43	11	3	0			1	1780	1624	1184
1999		40	363	253	222	139	58	8	2					1084	1044	681
2000		53	260	376	151	155	54	18	8		0	0		1075	1022	762
2001		49	406	318	183	46	21	9	6	1	0		0	1039	990	584
2002		5	140	345	120	69	12	10	9	1	1	0	0	712	707	567
2003		13	104	174	207	45	52	10	1	0	2	0		610	596	492
2004		23	300	133	55	26	7	2	0	0	0			546	523	223
2005		61	109	363	60	25	13	4	1	0	0	0		634	574	465
2006		0	50	36	121	20	2	1	1	0	0	0		231	230	181

Table 8c. Catch at age (numbers in thousands) for Bay of Fundy cod

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	2+	3+	4+
1993		242	1909	335	91	167	64	26	6	1	2			2843	2601	692
1994		157	1206	681	52	16	22	5	9	1	1			2150	1993	788
1995		22	947	409	281	46	9	22	9	1	0			1746	1724	776
1996		37	454	1186	211	109	11	10	8	1	0	0		2028	1991	1536
1997		88	733	761	654	103	33	4	2	5	1	0		2383	2295	1562
1998		270	469	421	238	234	38	14	4	1	1	1	1	1691	1421	953
1999	1	61	602	342	139	69	36	5	3	0	0	0		1256	1196	593
2000		158	358	516	103	50	12	11	3	1	0	0		1211	1054	696
2001		37	674	245	180	24	17	6	4	0				1187	1150	476
2002	0	17	225	754	101	68	19	5	3	3	0	0	0	1196	1179	954
2003		60	145	383	312	50	42	11	1	1	0	0		1005	944	800
2004		10	729	234	236	127	12	19	5	1	0	0	0	1374	1364	635
2005		6	39	468	113	64	34	5	2	0	0	0		733	727	688
2006		0	44	33	56	26	7	5	3	0	1	0	0	175	175	131

Table 9. Weights-at-age for 4X cod by area.

		1	2	3	4	5	6	7	8	9	10	11	12
	1983		0.76	1.22	1.81	2.50	3.93	6.09	8.22	10.76	11.83	12.22	16.59
	1984		0.96	1.30	1.69	2.34	3.37	4.68	6.83	8.60	11.06	13.21	14.03
	1985		0.60	1.07	1.47	2.00	3.06	4.55	6.70	6.89	9.00	14.16	15.66
	1986		0.78	1.13	1.63	2.21	3.47	4.69	7.15	8.83	8.81	13.11	13.10
	1987		1.23	1.40	1.83	2.61	3.46	4.99	7.33	8.36	10.66	11.80	15.85
Scotian	1988		0.94	1.30	1.90	2.69	3.98	5.23	8.06	9.88	10.93	13.05	16.04
Shelf	1989	0.78	1.23	1.57	2.21	2.75	3.96	4.88	7.86	9.46	11.95	15.04	14.81
	1990		0.82	1.29	1.97	2.86	3.72	5.59	8.10	10.46	11.93	14.12	15.24
	1991		0.76	1.13	1.73	2.50	3.54	5.08	6.44	9.44	11.19	13.73	15.74
	1992		0.78	1.14	1.63	2.58	3.58	4.44	6.50	8.37	12.10	14.50	19.15
	1993		0.67	1.21	1.66	2.28	3.44	4.49	6.61	9.67	11.08	17.30	
	1994		0.80	1.09	2.04	2.59	3.19	4.94	6.03	9.57	10.86	13.57	
	1995		0.85	1.23	1.87	3.45	4.13	4.82	7.58	9.92	13.35	16.39	
	1996		0.66	1.17	2.02	2.93	4.65	5.31	7.75	9.95	10.51	11.30	17.87
	1997		0.60	1.30	1.62	3.08	3.52	5.85	8.05	10.63	11.94	13.69	9.68
	1998		0.79	1.02	1.54	2.30	4.11	3.11	5.41	7.17	8.83		
	1999		0.80	1.72	2.16	2.87	3.78	5.03	8.29	12.23			
	2000		0.95	1.20	1.90	2.42	2.81	4.01	5.24	3.54		10.71	9.69
	2001		0.97	1.52	2.02	3.24	3.62	4.39	6.07	7.46	7.08	10.70	
	2002		0.75	1.26	2.16	2.79	4.33	5.06	6.14	6.12	6.98	6.79	0.00
	2003		0.94	1.37	1.85	3.59	4.45	5.52	5.95	10.06	12.15	12.77	0.00
	2004		0.81	1.25	2.29	3.60	5.10	5.18	7.04	8.91	0.00	0.00	0.00
	2005		1.07	1.47	2.16	3.73	4.42	5.64	6.95	10.45	9.69	0.00	0.00
	Mean	0.78	0.85	1.28	1.88	2.78	3.81	4.94	6.97	8.99	10.09	11.82	11.38
	1983	0.38	0.86	1.48	2.18	3.30	4.88	6.38	8.62	9.92	12.19	14.23	20.63
	1984	0.39	0.93	1.62	2.48	3.52	4.67	6.98	7.94	12.10	13.45	4.75	
	1985	0.37	0.84	1.48	2.26	3.43	4.53	6.54	9.45	11.46	15.12	18.23	19.52
	1986	0.37	0.80	1.41	2.33	4.30	6.24	7.36	8.18	9.50	14.25	7.99	11.98
	1987		0.84	1.57	2.56	4.17	5.33	7.04	7.92	7.94	14.31	18.56	
Bay of	1988		0.86	1.46	2.24	4.09	5.36	8.99	10.14	8.89	14.69		
Fundy	1989	0.33	0.76	1.52	2.59	3.60	6.33	7.25	10.32	10.55	14.57		11.66
	1990		1.05	1.69	2.69	3.77	4.37	7.31	8.15	11.32	11.95	12.75	14.74
	1991	0.82	1.04	1.88	2.91	4.26	6.77	8.75	11.02	13.60	14.17	15.10	17.93
	1992		1.18	1.73	2.73	4.49	6.51	8.78	9.93	13.13	14.55	11.10	
	1993		0.92	1.73	2.74	4.32	5.70	7.39	9.25	13.45	15.99	14.75	
	1994		1.08	1.74	3.15	4.84	6.61	8.68	10.12	11.49	10.40	11.62	
	1995		1.05	1.77	2.84	4.49	5.87	8.18	9.75	12.15	10.17	14.32	
	1996		0.99	1.63	2.72	4.21	5.50	6.37	8.85	11.25	13.54	15.05	13.19
	1997		0.93	1.65	2.57	4.30	5.87	8.09	9.56	10.98	12.87	14.45	22.03
	1998		1.14	1.84	2.77	3.65	5.41	6.22	8.90	10.75	10.33	10.52	15.75
	1999	0.70	1.32	1.94	2.97	4.30	5.16	7.56	6.73	11.04	13.19	8.41	19.10
	2000		1.24	2.07	3.31	4.00	5.68	7.11	7.65	6.24	6.13	10.59	15.52
	2001		1.30	2.00	3.24	4.57	5.86	7.48	8.26	10.62	12.38		
	2002	0.6167055	1.28	1.92	3.37	5.03	6.01	6.26	9.54	8.81	9.95	19.39	18.56
	2003		1.64	2.30	3.18	4.74	6.11	7.45	7.79	9.46	11.59	15.47	0.00
	2004		0.80	1.77	2.80	4.27	5.32	7.28	7.40	8.54	8.98	14.43	14.01
	2005		1.09	1.74	3.04	4.23	5.90	6.60	10.01	11.95	0.00	12.20	0.00
	Mean	0.50	1.04	1.74	2.77	4.17	5.65	7.39	8.93	10.66	11.95	13.20	14.31

Includes Jan – June 30, 2006

Table 10. ITQ survey indices for 4X cod.

4X	0	1	2	3	4	5	6	7	8	9	10
1996	1	302	662	835	737	84	31	6	0	2	0
1997	1	225	232	727	393	265	17	24	6	2	1
1998	16	179	857	619	276	112	112	15	7	0	0
1999	2002	601	700	708	170	98	15	24	5	1	0
2000	5	1063	1039	351	234	62	61	15	13	0	0
2001	907	234	2369	3391	382	142	5	21	5	6	0
2002	37	380	551	510	343	63	35	21	2	4	0
2003	37	283	1099	551	322	167	36	12	4	1	0
2004	7	370	142	746	258	98	48	8	2	3	0
2005	10	176	1196	71	248	18	16	1	0	0	1
2006	14	74	257	549	76	52	27	3	2	0	2

FUNDY	0	1	2	3	4	5	6	7	8	9
1996	1	259	487	359	427	61	13	1	0	1
1997	0	207	126	529	204	182	10	17	5	1
1998	16	150	754	493	186	40	69	4	1	0
1999	2000	506	412	526	92	50	8	22	5	0
2000	3	955	738	156	135	21	6	4	4	0
2001	907	115	2120	3196	298	83	2	5	0	0
2002	35	343	97	277	253	25	20	17	2	0
2003	36	278	771	133	213	137	32	9	2	0
2004	6	348	92	361	33	28	16	1	1	1
2005	10	148	703	22	115	8	7	1	0	0
2006	11	64	117	87	18	14	9	1	0	

Shelf	0	1	2	3	4	5	6	7	8	9	10
1996	0	43	175	476	310	23	17	5	0	1	0
1997	1	18	106	198	189	83	7	7	1	1	1
1998	0	29	103	126	89	71	44	11	6	0	0
1999	2	95	287	182	78	48	7	2	0	1	0
2000	2	108	301	196	98	42	55	11	9	0	0
2001	0	119	249	195	84	59	3	16	5	6	0
2002	2	37	454	233	89	39	14	4	0	4	0
2003	1	5	328	418	109	30	3	3	2	1	0
2004	1	22	50	385	225	70	32	7	1	2	0
2005	0	28	492	49	133	10	9	0	0	0	0
2006	3	10	141	463	58	37	19	2	2		

Table 11. RV survey stratified numbers for 4X cod

Age	0	1	2	3	4	5	6	7	8	9	10	11	12+
1983	208	141	1085	4226	2369	1480	946	389	0	77	37	0	6
1984	0	820	5746	3390	2362	1820	688	482	63	58	25	0	0
1985	69	495	8760	4331	1527	1451	766	483	267	165	13	0	26
1986	25	768	1333	2920	1226	314	549	448	217	97	19	0	51
1987	6	392	2348	618	1180	528	260	245	304	75	40	63	0
1988	260	2630	3926	9246	1496	1548	496	210	244	91	38	13	0
1989	309	794	6089	3420	2549	420	489	108	27	82	37	14	0
1990	28	515	873	5523	2463	2321	240	414	80	42	0	21	27
1991	34	614	1727	1131	3086	1094	751	128	116	19	21	12	0
1992	35	252	2731	1569	681	1710	471	460	124	85	0	0	0
1993	14	369	955	2518	925	129	265	52	61	0	6	41	0
1994	748	1258	3313	2739	1605	449	36	195	88	70	0	32	65
1995	1212	122	847	4779	1477	598	274	94	91	34	42	7	0
1996	31	339	839	2048	5527	880	753	148	0	56	15	0	0
1997	95	349	569	1189	1444	2462	321	194	100	0	57	0	0
1998	65	211	1929	1808	1418	1022	1371	225	116	6	0	0	0
1999	869	382	787	1291	882	850	194	297	46	0	0	0	0
2000	3324	432	1497	830	999	409	325	157	148	0	0	0	21
2001	908	150	1984	2272	1476	816	347	217	148	31	0	0	0
2002	110	5196	1990	2565	2472	496	302	121	19	98	0	0	0
2003	715	499	3005	544	1102	745	189	78	20	19	0	0	0
2004	167	31	272	2977	319	324	113	27	8	0	0	0	0
2005	54	250	1741	368	1820	223	208	35	0	35	0	17	0
2006	269	108	812	1831	393	348	162	20	0	0	0	0	0

Table 11 (cont.). RV survey stratified numbers for cod on the Scotian Shelf

Age	0	1	2	3	4	5	6	7	8	9	10	11	12+
1983	136	107	571	3157	1914	937	546	146	0	13	0	0	6
1984	0	354	1417	1376	1201	1507	538	416	0	36	0	0	0
1985	69	90	837	834	343	456	483	314	77	0	13	0	26
1986	0	19	616	947	509	151	435	349	195	0	19	0	51
1987	6	79	1229	305	325	250	106	68	187	26	0	0	0
1988	27	793	1602	5143	1317	887	228	107	57	91	38	13	0
1989	301	136	2910	1789	1723	230	227	89	0	30	18	14	0
1990	28	151	213	2187	1419	1319	113	108	0	0	0	0	7
1991	34	147	1107	599	1833	722	545	80	7	19	0	0	0
1992	35	108	547	981	359	946	405	224	104	29	0	0	0
1993	14	33	296	664	502	80	82	32	61	0	6	41	0
1994	92	380	1073	626	610	268	19	51	50	50	0	0	33
1995	216	33	534	2107	1059	248	229	47	32	34	0	7	0
1996	31	207	374	1307	2378	303	429	148	0	24	15	0	0
1997	30	126	399	560	850	1225	128	109	100	0	26	0	0
1998	39	0	441	599	495	557	503	97	55	6	0	0	0
1999	677	69	330	730	675	736	165	98	0	0	0	0	0
2000	3263	86	151	246	265	230	223	144	148	0	0	0	21
2001	908	150	487	1441	477	406	22	60	0	31	0	0	0
2002	110	59	247	430	547	306	141	49	0	25	0	0	0
2003	258	11	234	210	227	144	15	30	0	0	0	0	0
2004	122	31	74	480	192	205	34	27	8	0	0	0	0
2005	11	159	924	142	632	60	57	15	0	35	0	17	0
2006	60	13	135	574	218	171	63	0	0	0	0	0	0

RV survey stratified numbers for cods in the Bay of Fundy and Gulf of Maine

age	0	1	2	3	4	5	6	7	8	9	10	11	12+
1983	71	34	514	1069	456	543	400	244	0	63	37	0	0
1984	0	466	4328	2015	1161	313	150	66	63	23	25	0	0
1985	0	404	7923	3497	1184	995	283	169	190	165	0	0	0
1986	25	749	718	1974	717	163	114	99	21	97	0	0	0
1987	0	313	1118	313	855	278	154	177	117	49	40	63	0
1988	233	1837	2323	4103	179	661	268	103	187	0	0	0	0
1989	9	658	3179	1632	826	190	262	20	27	52	19	0	0
1990	0	364	660	3335	1044	1002	128	306	80	42	0	21	21
1991	0	466	620	532	1253	372	206	48	109	0	21	12	0
1992	0	144	2184	588	322	765	66	237	21	56	0	0	0
1993	0	336	659	1854	423	49	183	20	0	0	0	0	0
1994	657	878	2240	2113	996	180	16	143	38	20	0	32	32
1995	996	89	313	2671	418	351	45	47	60	0	42	0	0
1996	0	132	465	740	3149	578	324	0	0	32	0	0	0
1997	65	223	170	629	594	1236	194	85	0	0	31	0	0
1998	26	211	1488	1209	923	465	868	128	61	0	0	0	0
1999	192	313	457	561	207	115	29	199	46	0	0	0	0
2000	61	346	1346	585	734	179	102	12	0	0	0	0	0
2001	1262	0	567	1449	474	240	22	0	0	0	0	0	0
2002	0	4269	1743	2143	1954	214	183	73	19	73	0	0	0
2003	457	488	2771	334	875	601	174	49	20	19	0	0	0
2004	45	0	199	2497	127	119	79	0	0	0	0	0	0
2005	43	91	818	226	1187	162	151	20	0	0	0	0	0
2006	209	95	678	1257	175	178	99	20	0	0	0	0	0

Table 12. Population abundance (number in 000's) for 4X cod from a virtual population analysis (formulation from Clark and Paul, 1999).

Numbers	1	2	3	4	5	6	7	8	9	10	11	12
1980	22650.7	23235.0	22360.8	8482.5	4816.6	3072.7	1389.5	849.3	309.8	211.9	79.6	54.6
1981	25602.8	18544.8	18267.6	12870.6	4827.6	2383.0	1499.2	741.2	461.2	172.0	119.6	48.1
1982	13810.0	20961.8	14444.9	11475.7	6713.5	2301.6	1017.1	702.0	341.1	212.9	73.8	62.9
1983	13708.6	11306.7	16346.1	9231.1	5444.0	2763.5	1068.3	480.9	325.1	148.7	97.4	23.9
1984	17176.4	11215.6	8327.4	10066.4	5372.4	2615.3	1185.6	464.3	211.4	158.7	54.0	47.5
1985	9275.0	14033.0	8355.5	4669.8	5477.3	2669.5	1277.0	554.5	222.5	116.5	86.0	18.4
1986	26638.7	7593.7	10847.6	5334.9	2416.7	2406.5	1039.8	585.6	280.1	118.5	48.0	54.2
1987	18161.5	21809.9	5990.6	6375.7	2629.2	1089.5	1068.9	485.2	300.2	146.0	52.3	18.8
1988	26510.1	14869.4	17079.3	4092.4	3378.8	1180.4	425.3	419.1	186.7	120.8	60.5	13.6
1989	8811.4	21704.7	11810.1	10819.8	1866.3	1379.4	382.7	189.0	171.6	77.0	51.5	24.6
1990	12835.4	7198.8	17178.9	7367.2	5581.1	961.5	626.6	167.6	84.1	86.8	45.9	33.2
1991	13582.9	10508.8	5763.8	11487.4	3520.4	2369.4	344.3	263.7	67.6	33.2	37.1	25.0
1992	9047.8	11118.9	8250.9	3340.3	4855.2	1297.9	727.3	91.2	77.3	26.8	12.9	5.7
1993	14168.3	7407.7	8425.9	3722.1	1064.3	1077.3	286.1	142.5	19.0	19.0	7.7	2.6
1994	7376.9	11600.1	5270.9	3777.1	1227.3	285.9	286.0	69.5	36.9	3.2	3.2	1.9
1995	5567.6	6039.7	9068.6	2277.5	1108.7	222.6	61.7	73.7	19.6	14.2	2.6	0.9
1996	3682.0	4558.4	4823.0	5495.8	899.8	389.2	66.7	25.5	24.7	6.3	7.1	2.1
1997	5235.2	3014.5	3686.9	3154.1	2184.1	343.3	130.0	28.7	6.7	13.1	3.3	4.9
1998	3280.2	4286.2	2414.8	2008.3	1194.5	726.3	104.2	33.7	9.3	3.7	5.3	1.8
1999	6335.9	2685.6	3298.1	1183.5	734.1	429.8	203.1	37.2	9.8	2.3	1.2	1.7
2000	2957.0	5187.4	2133.8	1950.9	484.0	291.3	117.6	59.7	12.6	1.9	1.9	1.0
2001	2133.0	2421.0	4050.3	1230.6	789.2	176.1	71.0	37.6	24.8	3.2	0.6	0.6
2002	5096.5	1746.4	1879.2	2250.7	476.6	308.8	77.1	22.6	15.6	9.6	1.8	0.5
2003	1020.4	4172.7	1410.0	1210.2	862.3	192.9	129.5	35.4	4.4	1.4	4.3	0.5
2004	5164.8	835.5	3350.4	930.3	493.4	245.1	72.3	22.3	10.3	1.8	0.3	0.8
2005	1905.8	4228.6	654.2	1819.8	433.2	145.4	65.0	42.1	1.0	4.0	0.6	0.2
2006	5000.0	1560.4	3402.5	402.6	748.6	199.9	40.1	11.8	26.4	0.0	3.3	0.5
2006.5	4524.2	1411.9	2990.3	298.8	508.5	138.1	27.7	4.0	21.0	0.0	2.0	0.4

Table 13. Annual estimates of catchability (q) calculated from the population matrix and RV survey indices

catchability	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*Avg. 4-7*
1983	0.10	0.26	0.26	0.27	0.34	0.36	0.00	0.24	0.28
1984	0.51	0.41	0.23	0.34	0.26	0.41	0.14	0.27	0.28
1985	0.62	0.52	0.33	0.26	0.29	0.38	0.48	0.74	0.30
1986	0.18	0.27	0.23	0.13	0.23	0.43	0.37	0.35	0.23
1987	0.11	0.10	0.19	0.20	0.24	0.23	0.63	0.25	0.20
1988	0.26	0.54	0.37	0.46	0.42	0.49	0.58	0.49	0.41
1989	0.28	0.29	0.24	0.23	0.35	0.28	0.14	0.48	0.25
1990	0.12	0.32	0.33	0.42	0.25	0.66	0.48	0.50	0.37
1991	0.16	0.20	0.27	0.31	0.32	0.37	0.44	0.28	0.29
1992	0.25	0.19	0.20	0.35	0.36	0.63	1.36	1.10	0.33
1993	0.13	0.30	0.25	0.12	0.25	0.18	0.43	0.00	0.22
1994	0.29	0.52	0.42	0.37	0.13	0.68	1.27	1.90	0.41
1995	0.14	0.53	0.65	0.54	1.23	1.52	1.24	1.73	0.67
1996	0.18	0.42	1.01	0.98	1.93	2.22	0.00	2.27	1.07
1997	0.19	0.32	0.46	1.13	0.94	1.49	3.48	0.00	0.76
1998	0.45	0.75	0.71	0.86	1.89	2.16	3.44	0.65	1.00
1999	0.29	0.39	0.75	1.16	0.45	1.46	1.24	0.00	0.87
2000	0.29	0.39	0.51	0.84	1.12	1.33	2.48	0.00	0.66
2001	0.82	0.56	1.20	1.03	1.97	3.05	3.94	1.25	1.26
2002	1.14	1.36	1.10	1.04	0.98	1.57	0.84	6.28	1.09
2003	0.72	0.39	0.91	0.86	0.98	0.60	0.56	4.35	0.88
2004	0.33	0.89	0.34	0.66	0.46	0.37	0.36	0.00	0.45
2005	0.41	0.56	1.00	0.51	1.43	0.54	0.00	35.95	0.93
2006	0.52	0.54	0.98	0.46	0.81	0.50	0.00	0.00	0.66
weighted avg 83-93	0.256	0.329	0.260	0.308	0.299	0.405	0.391	0.407	
weighted avg 95-05	0.395	0.562	0.805	0.914	1.267	1.450	1.663	2.011	

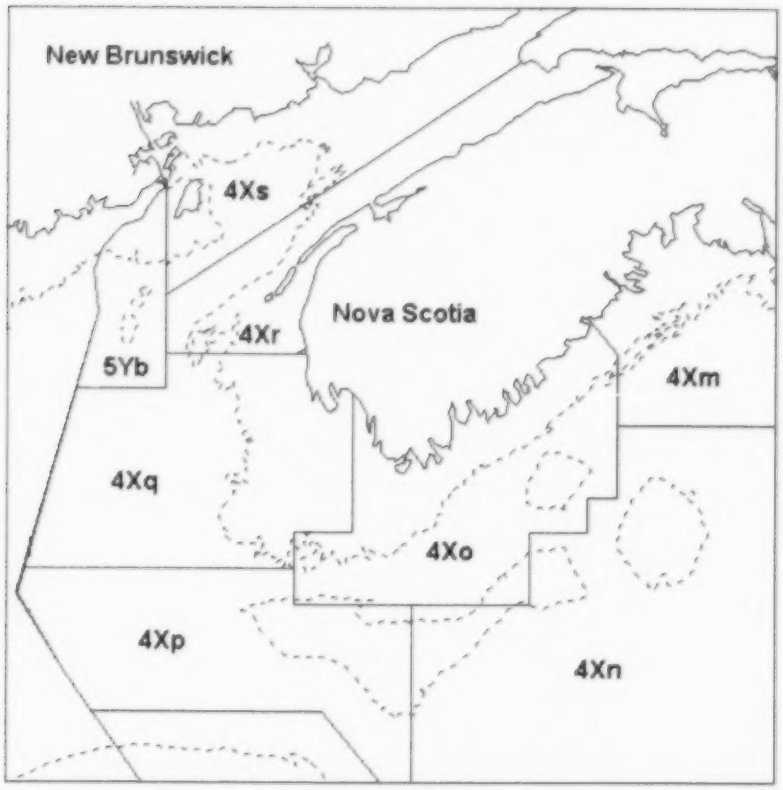


Figure 1. Canadian statistical unit areas in southern Scotian Shelf and Bay of Fundy.

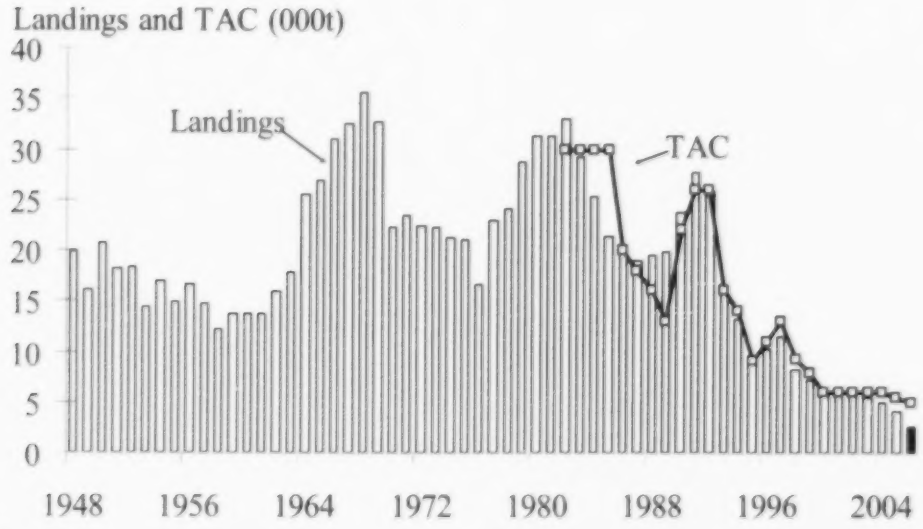


Figure 2. Nominal landings and quota (TAC) of cod in Division 4X and Canadian portion of 5Y by quota year (2006 landings for partial year).

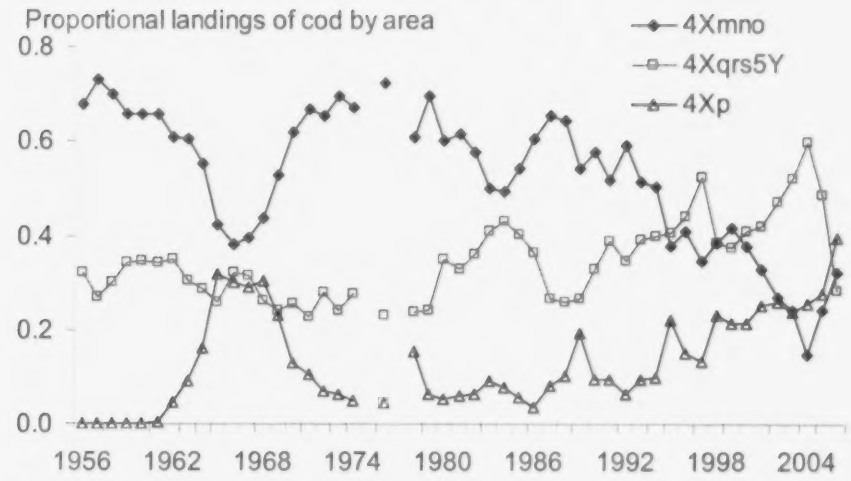
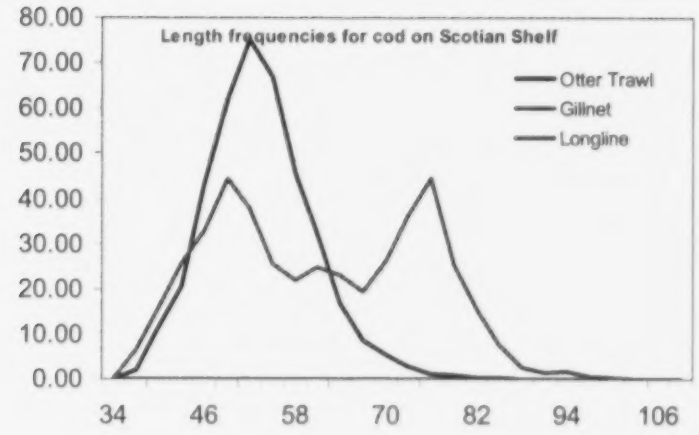


Figure 3. Proportion of 4X cod landings by region.



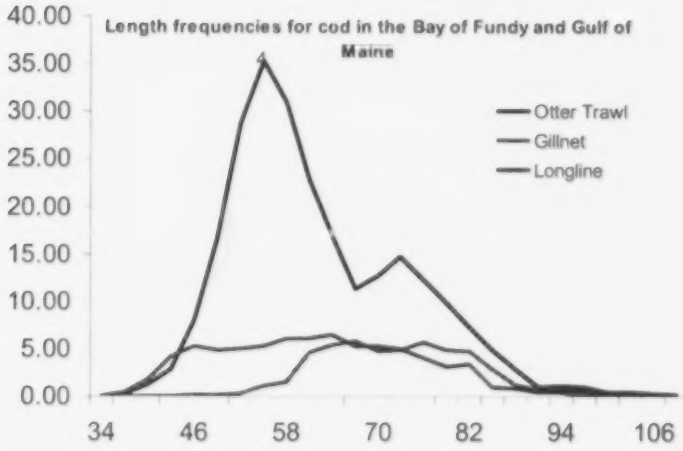


Figure 4. Proportion at length (cm) in commercial landings of 4X cod by area and gear type in 2006.

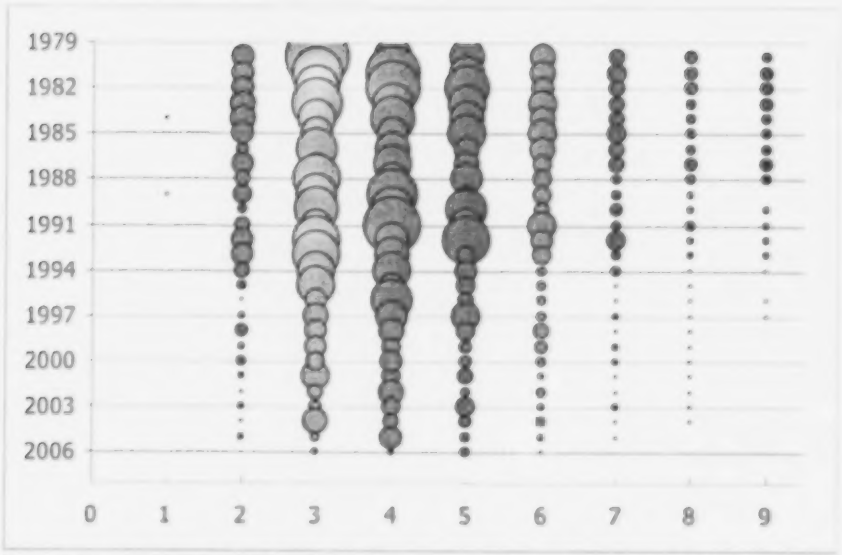


Figure 5a. Commercial catch-at-age for 4X cod. Area of circle is proportional to catch in numbers.

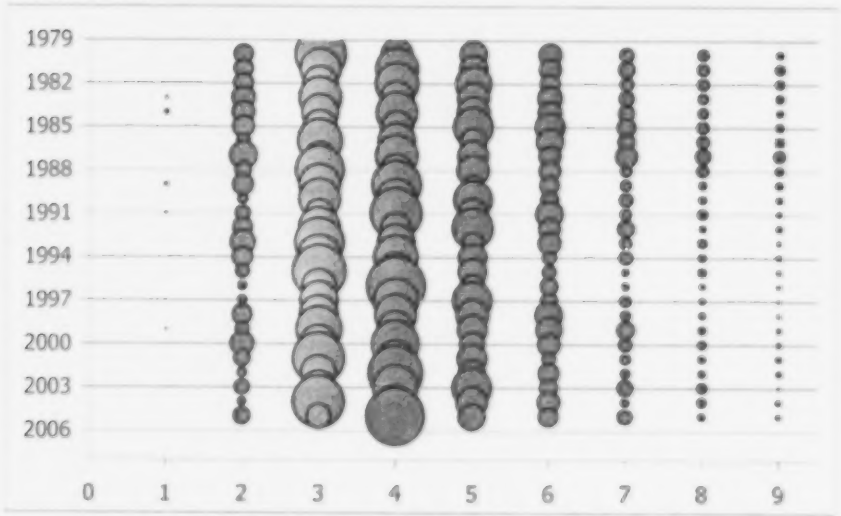


Figure 5b. Proportional catch at age by year for 4X cod. Area of circle reflects the proportion of the total catch at each age in that year.

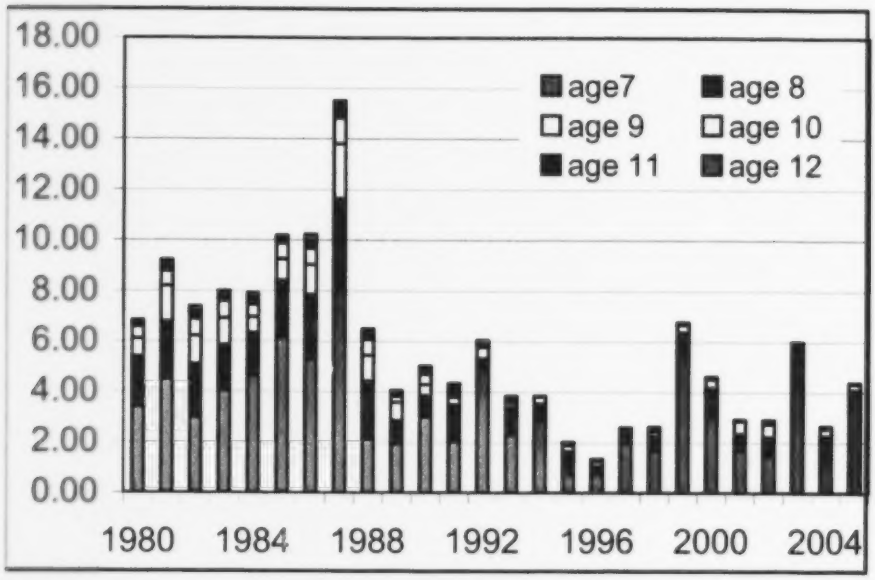


Figure 5c. Proportion of the catch at ages 7 and over for 4X cod since 1980.

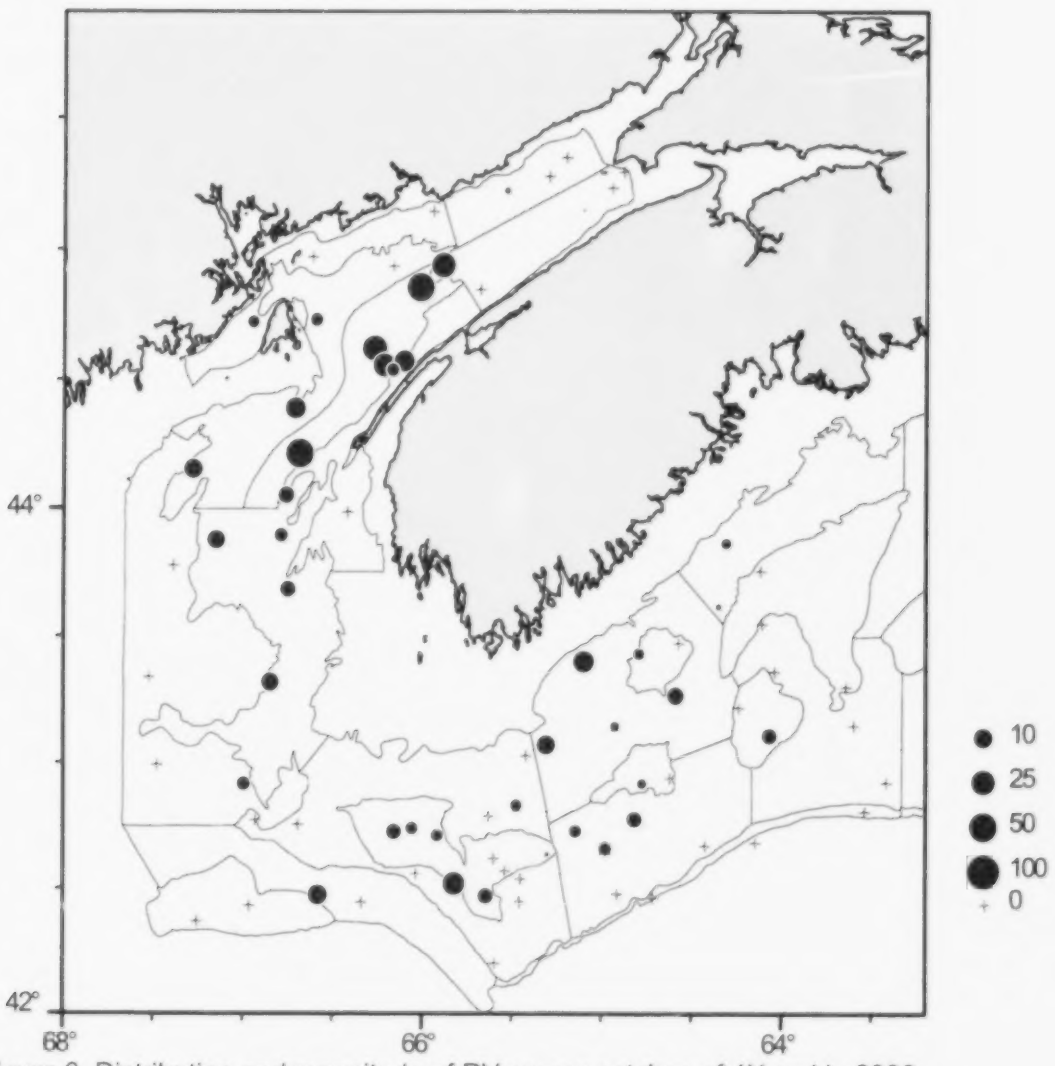


Figure 6. Distribution and magnitude of RV survey catches of 4X cod in 2006.

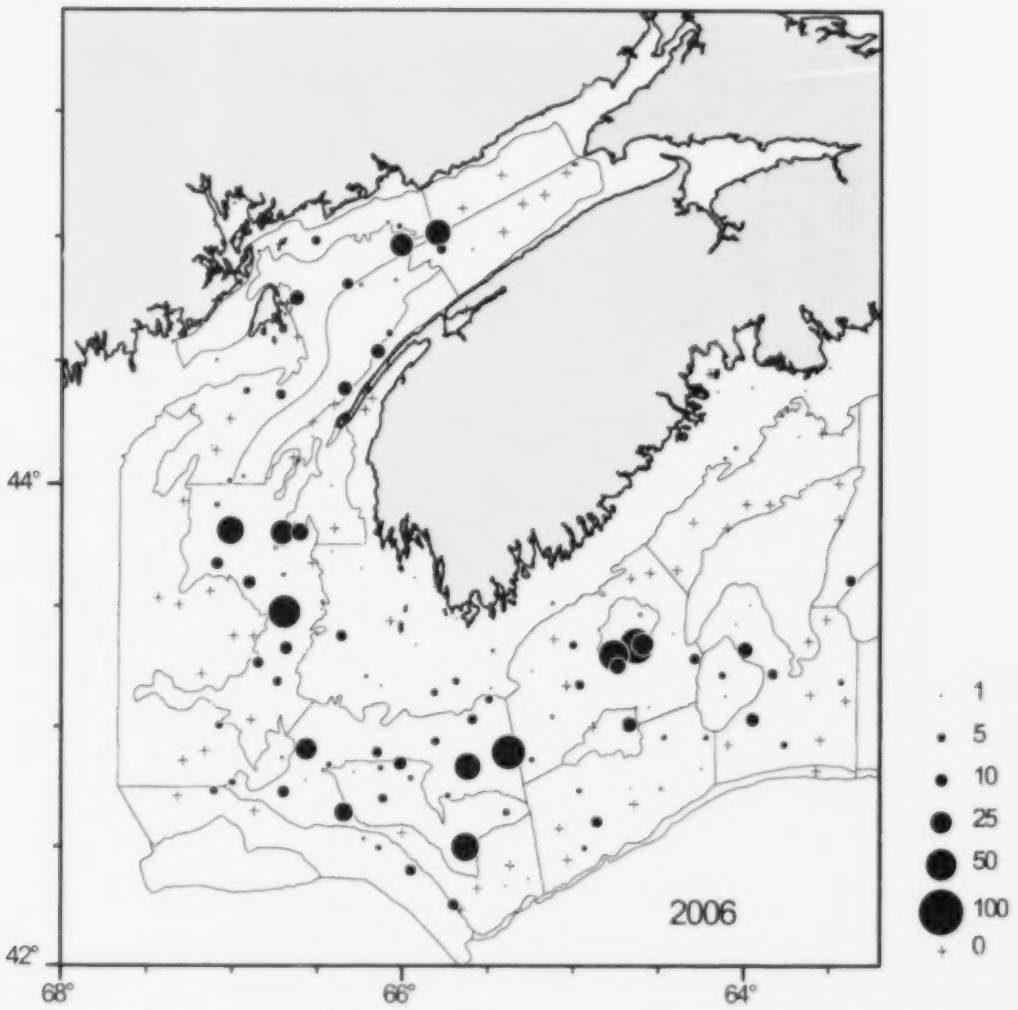


Figure 7. Distribution and magnitude of ITQ survey catches of 4X cod in 2006.

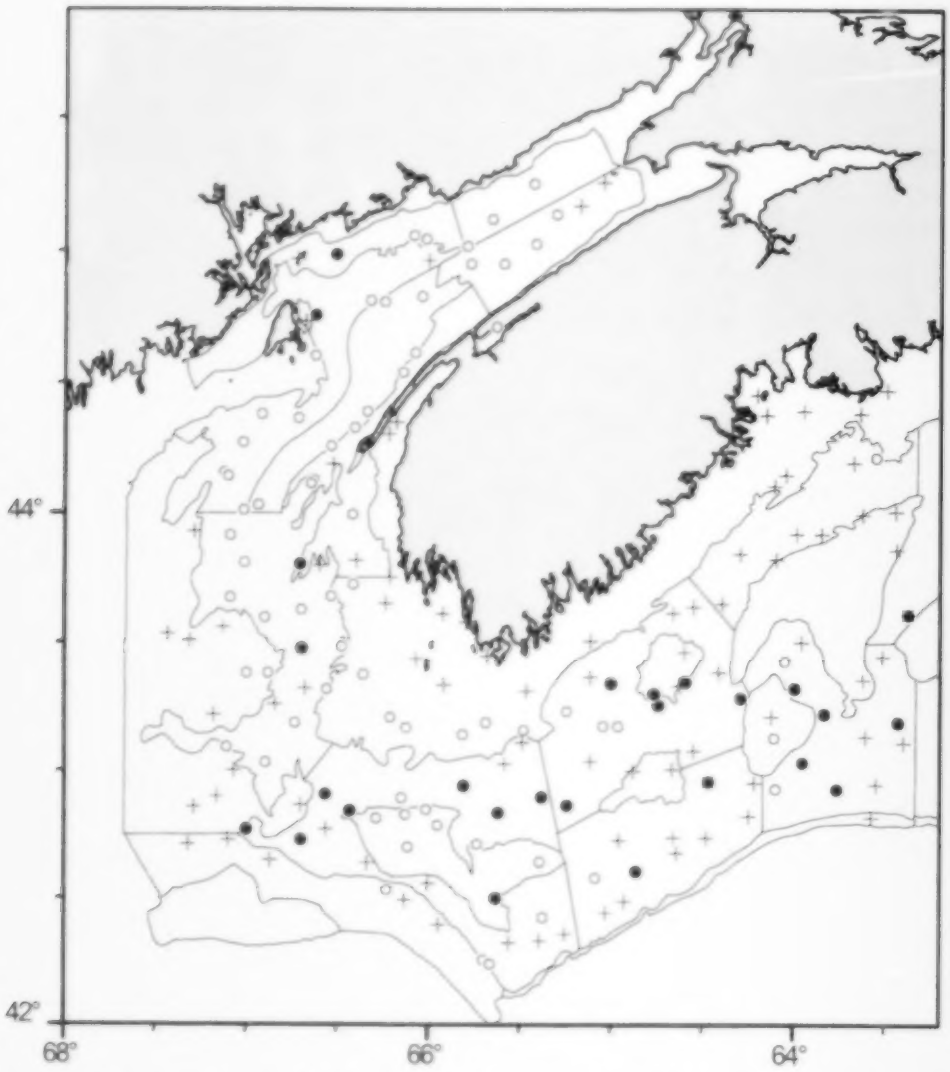


Figure 8. A comparison of ITQ survey cod catches for 2006 with the median value for each station since 1996. • 2006 value>median; + 2006 value is within 1 of the median; o 2006 value<median.

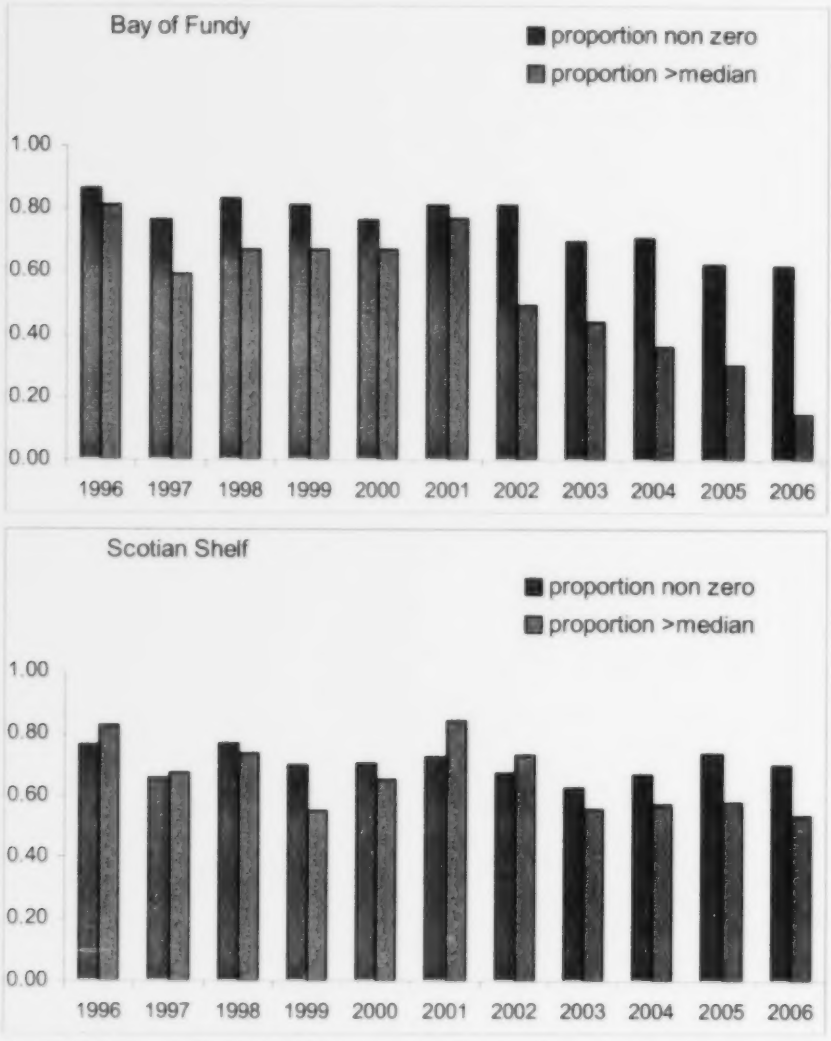


Figure 9. Proportion of ITQ survey stations where cod were caught, and where catch was above the median for that location (1996-2005).

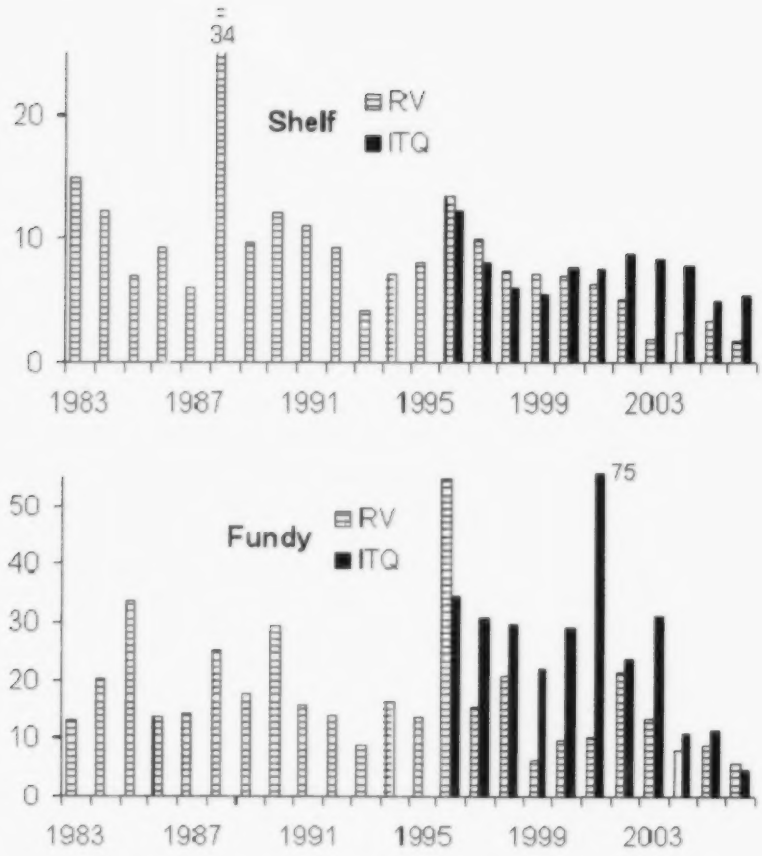


Figure 10. RV and ITQ survey biomass indices (Kg/tow) for 4X cod in the Bay of Fundy and the Scotian Shelf.

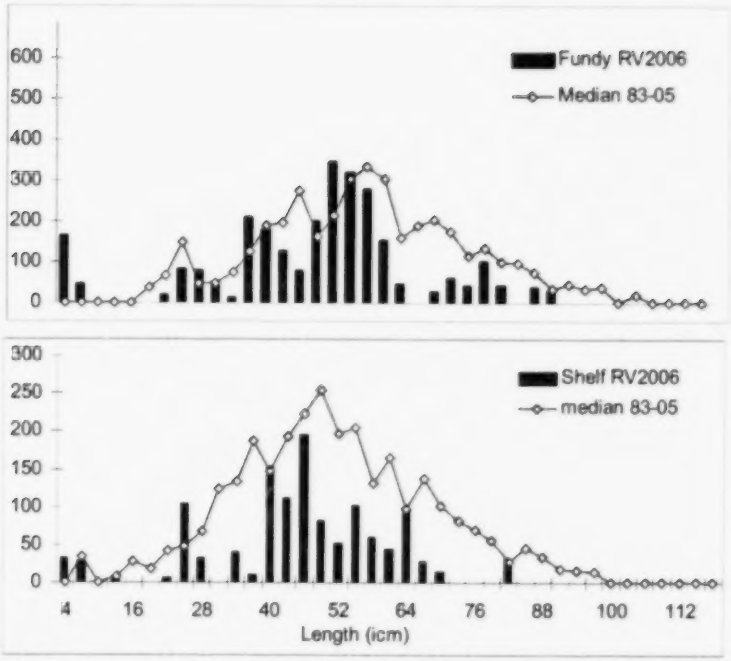


Figure 11. Length frequencies for 4X cod caught in the 2006 RV survey.

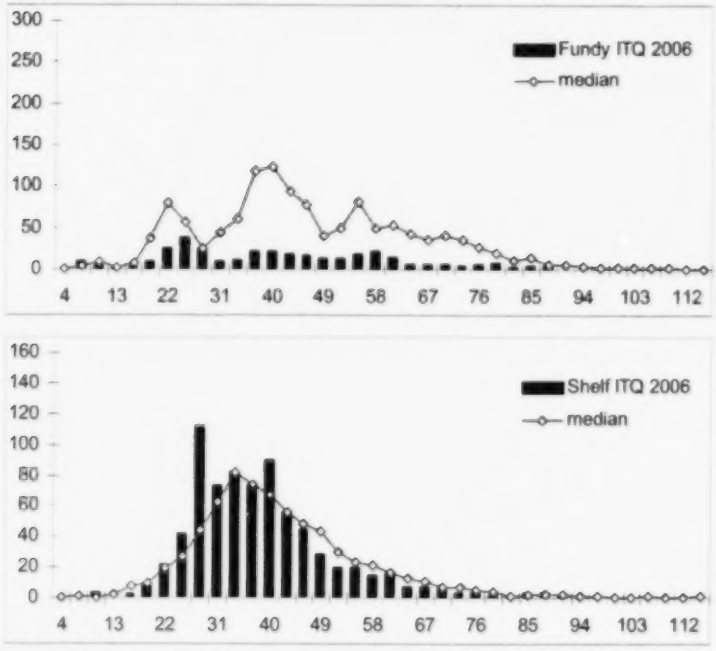


Figure 12. Length frequencies for 4X cod caught in the 2006 ITQ survey.

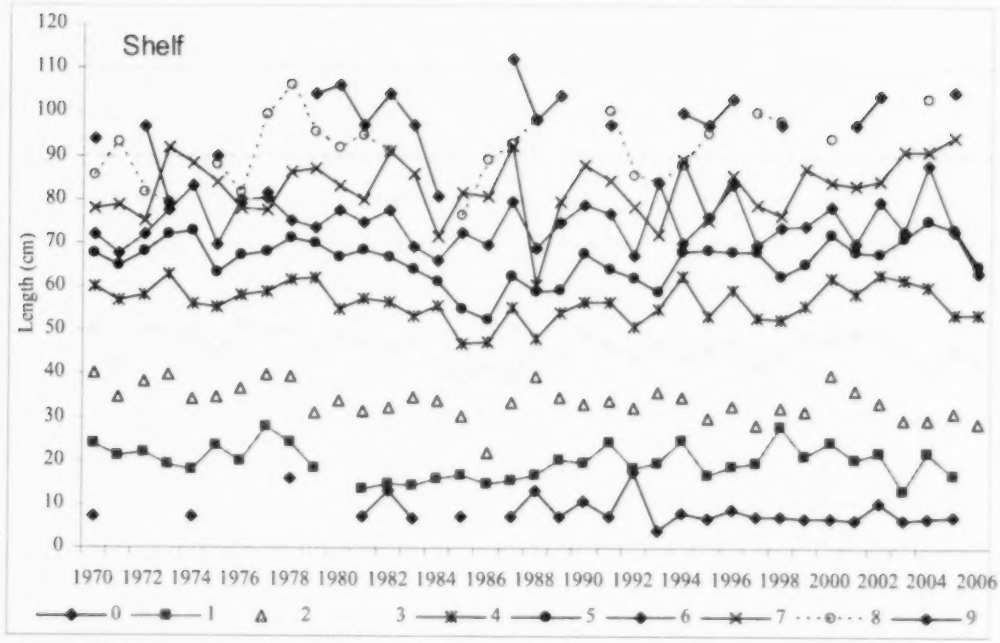


Figure 13a. Lengths-at-age for cod on the Southern Scotian Shelf.

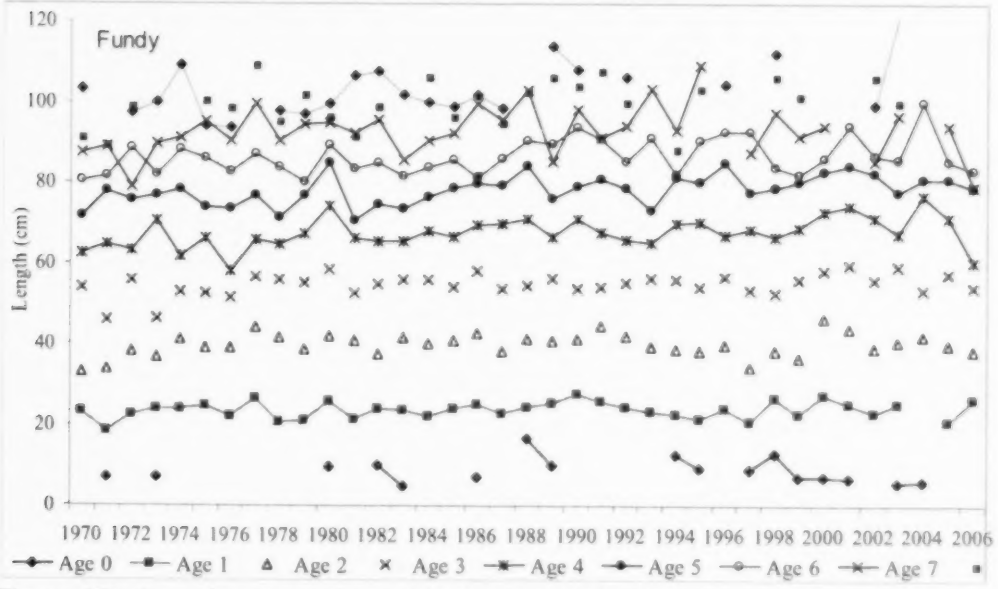


Figure 13b. Lengths-at-age for cod in the Bay of Fundy.

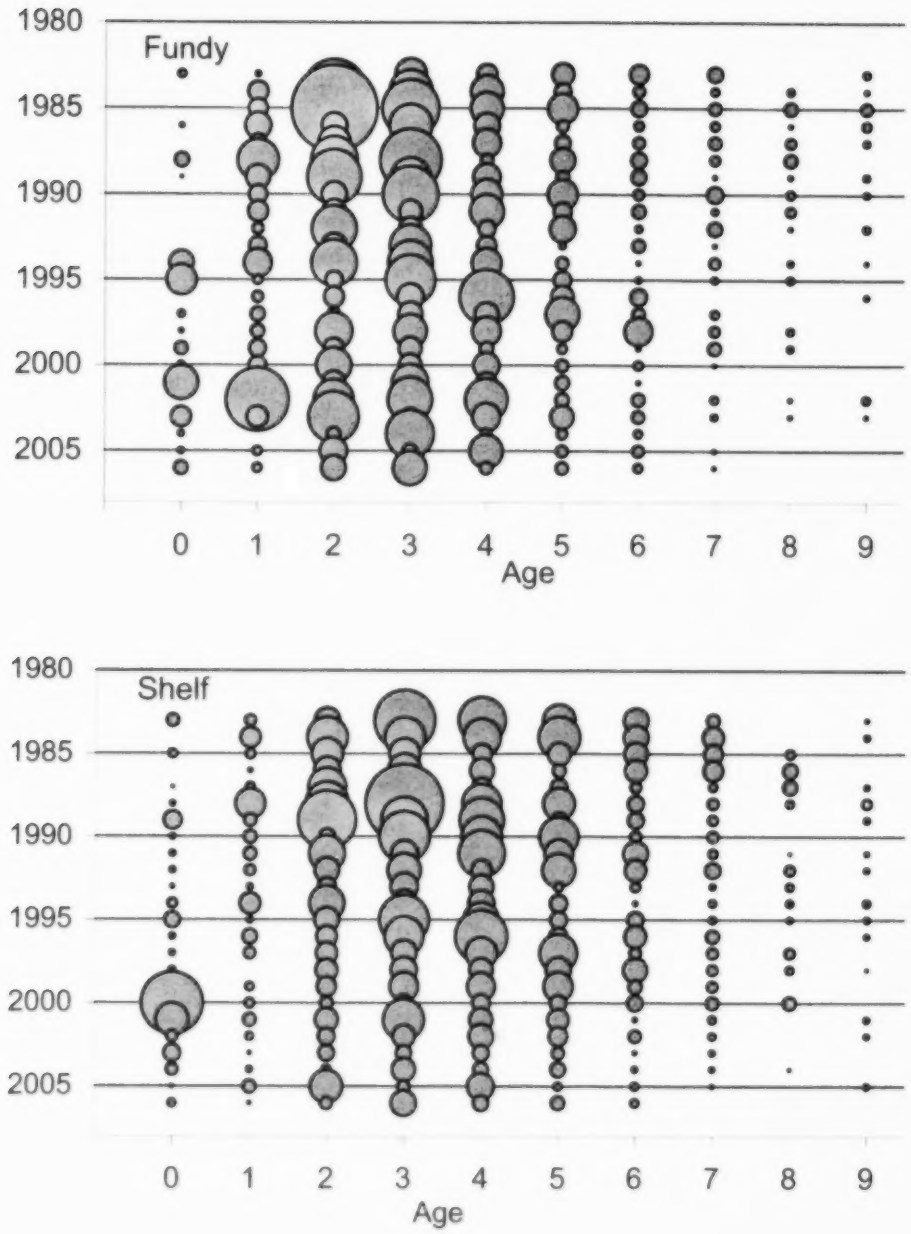


Figure 14. RV survey indices at age by area for 4X cod (survey catch is proportional to area of circle).

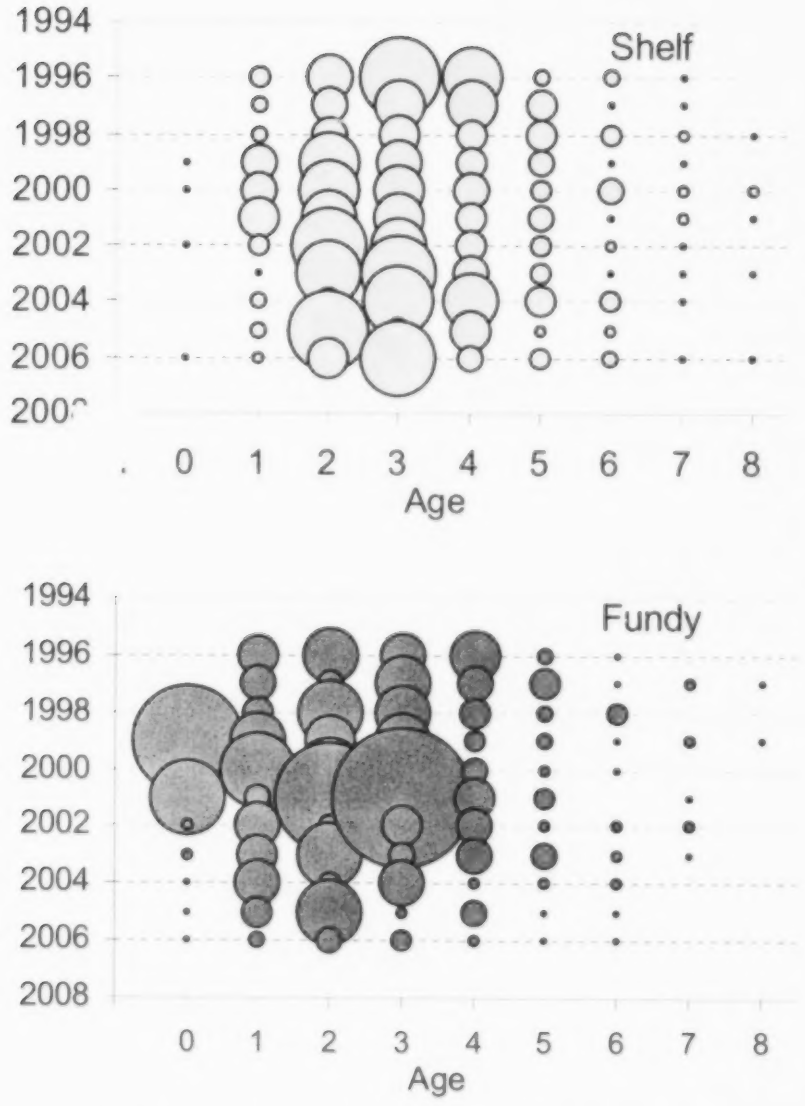


Figure 15. ITQ survey indices at age for 4X cod (survey catch is proportional to area of circle).

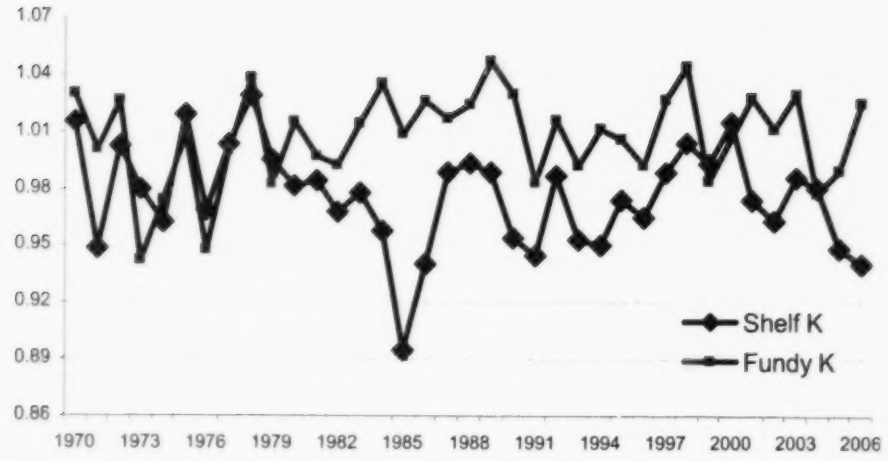


Figure 16. Condition factor (Fulton's K) from the RV survey.

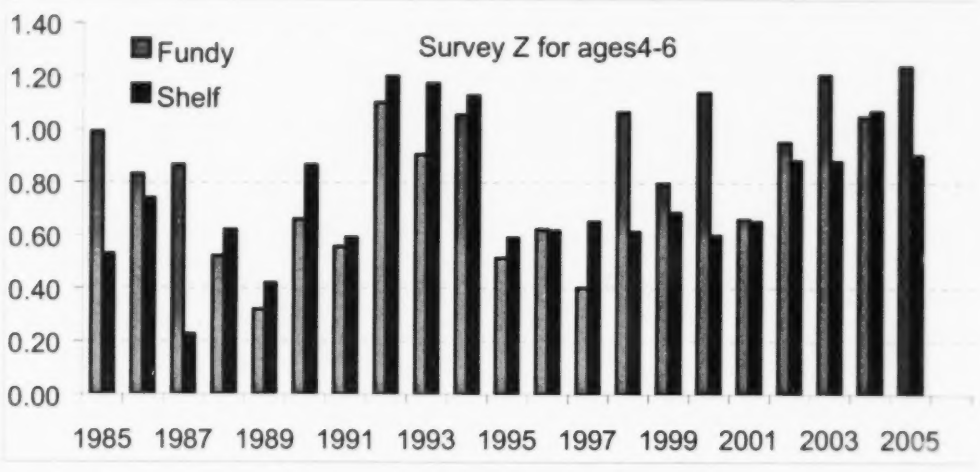


Figure 17. Total mortality estimate (Z) from the RV survey for 4X cod (3-yr. smooth).

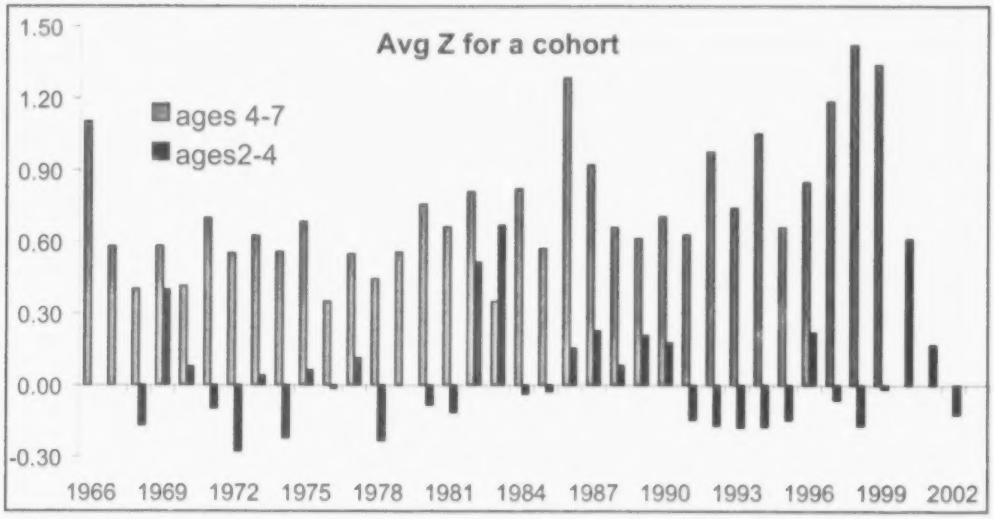


Figure 18. Total mortality estimate (Z) from the RV survey for a cohort at commercial (4-7) and recruiting (2-4) ages.

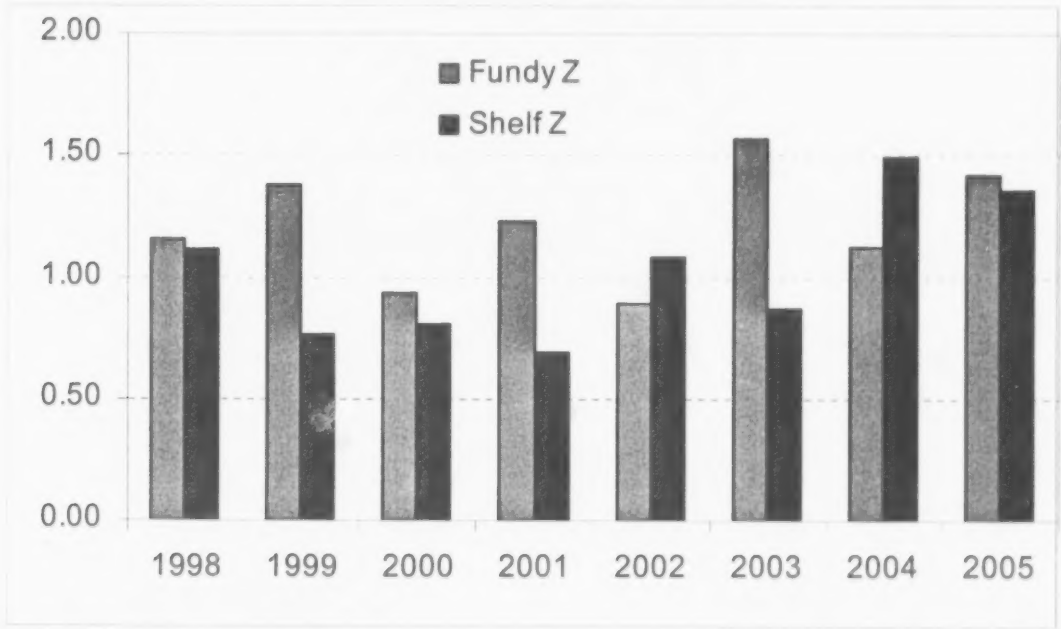


Figure 19. Total mortality estimate (Z) from the ITQ survey for 4X cod.

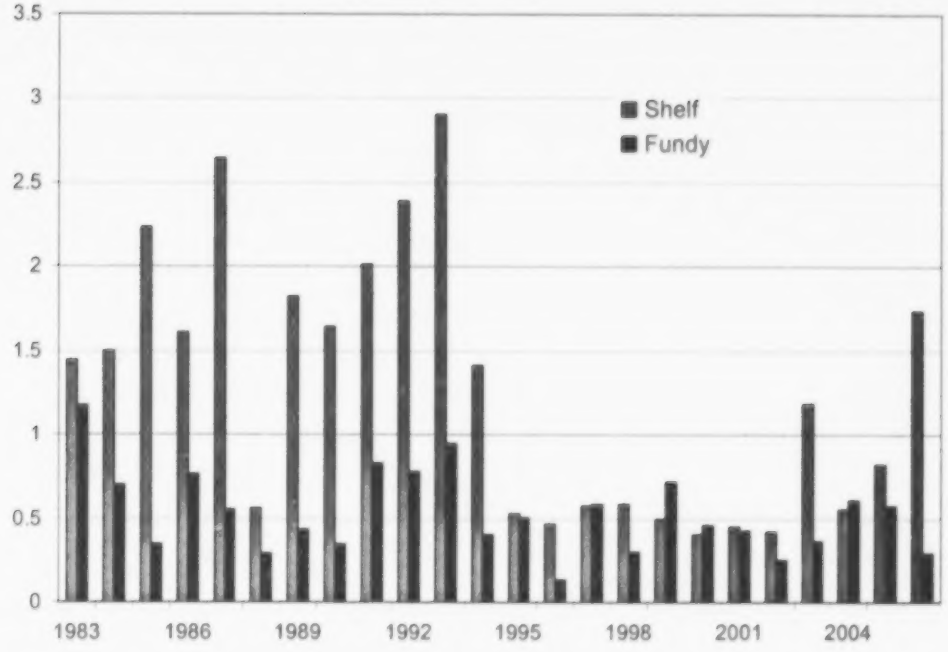


Figure 20. Relative fishing mortality by region for 4X cod.

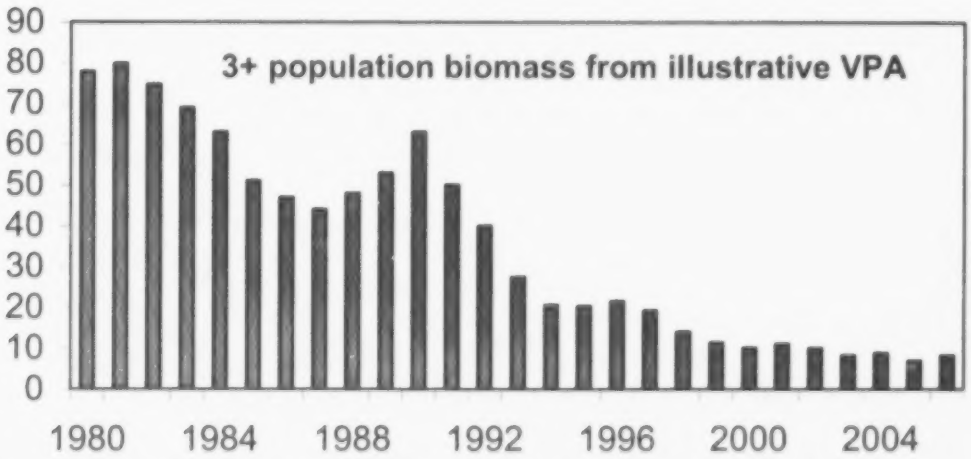


Figure 21. Population biomass estimates (age 3+) from an illustrative VPA (formulation from Clark and Paul, 1999).

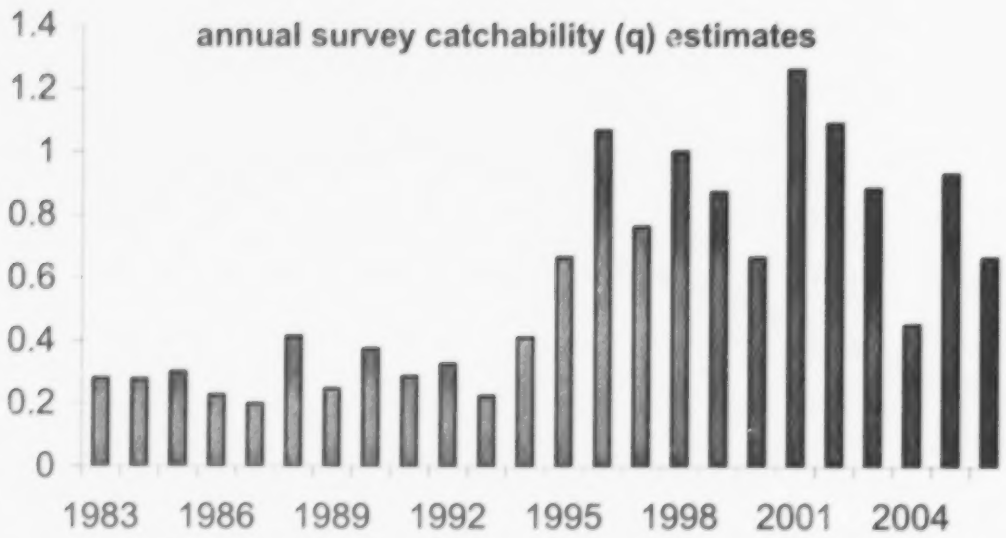


Figure 22. Annual survey catchability estimates (ages 4-7) calculated from RV survey indices and population abundance estimates from an illustrative VPA ((formulation from Clark and Paul, 1999).

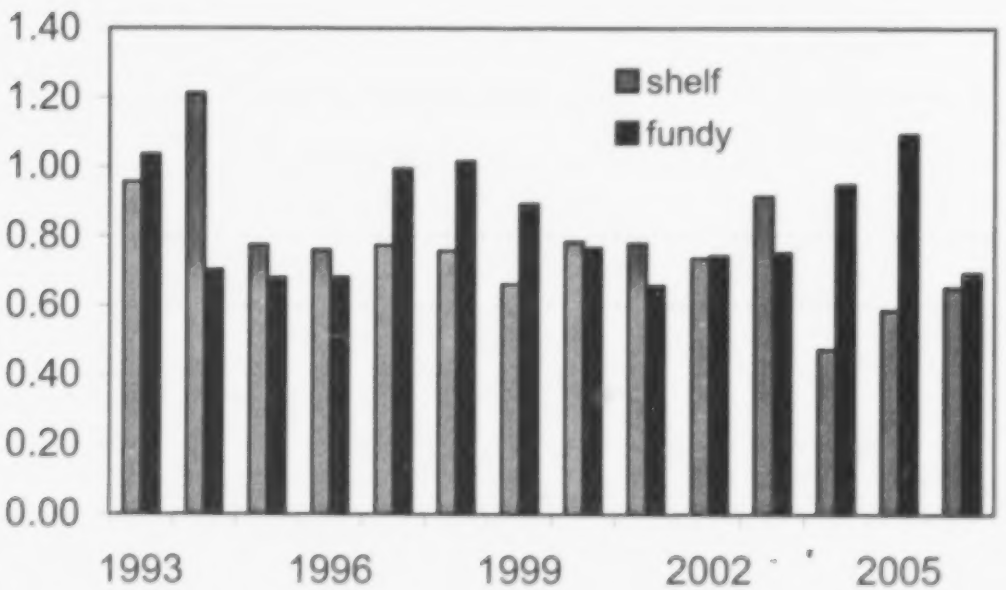


Figure 23. Fishing mortality estimates for ages 4-6 from VPA's run for Bay of Fundy and Scotian Shelf separately (VPA formulation as in Clark and Paul, 1999).